Solar Pico PV Market Potential in Nepal

Current Trend and Future Perspective

SNV

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Foreword

The Netherlands Development Organisation (SNV) is dedicated to a society where all people enjoy the freedom to pursue their own sustainable development. SNV contributes to this by strengthening the capacity of local organisations. SNV concentrates its work on issues related to food, energy and water, three areas posing some of the most urgent development challenges for people living in poverty.

When it comes to energy, we believe that access to affordable energy is an essential prerequisite to achieve economic growth and poverty reduction. Hence, with energy poverty to remain a challenge for Nepal in the coming decades, SNV looks to provide access to clean cooking and lighting solutions for households. At the same time we look into opportunities for rural electrification and the use of renewable energy for productive end uses for households and entrepreneurs.

SNV Nepal, in partnership with relevant NGOs, private sector and government agencies is exploring the potential to implement a solar lantern programme, to establish and promote sustainable and commercially viable supply and distribution models for affordable, clean and efficient lighting products and services, with the potential for scaling up across the country. By doing so, SNV aims at increasing access to and use of modern lighting solutions. Combined with our ongoing clean cooking work this will allow us to fulfil the dual needs (cooking and lightinglighting) of poor households and presents a valuable response to the Government of Nepal's call to achieve clean cooking and lightinglighting for all.

This study on the Nepal PicoPV market in Nepal sets out to gather district specific data related to: household lighting energy supply and consumption patterns; awareness on the technology and willingness to pay;lighting technologies available in the market; availability of financing options, as well as the current distribution and retailing chain for Pico PV products. The findings presented in this report will serve as a reference document of the current status, while assisting us to fine-tune future interventions.

Guy Dekelver
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Abbreviations

AEPC	Alternative Energy Promotion Center
BCU	Biogas Credit Unit
BS	Bikram Sammat
CBS	Central Bureau of Statistics
CDR	Central Development Region
CESPS	Community Energy Service Providers
CFL	Compact Fluorescent Lamp
CRE	Center for Renewable Energy
CREF	Central Rural Energy Fund
DANIDA	Danish International Development Agency
DEEUs	District Energy and Environment Units
EDR	Eastern Development Region
ESAP	Energy Sector Assistance Programme
FWDR	Far Western Development Region
FYI	Fiscal Year
GIZ	German Federal Enterprise for International Cooperation
GoN	Government of Nepal
GW	Giga Watt
HH	Household
ICT	Information Communication Technology
IEA	International Energy Agency

IFC	International Finance Corporation
INGOS	International Non-Governmental Organisation
IRENA	International Renewable Energy Agency
ISPS	Institutional Solar PV Systems
KFW	Kreditanstalt für Wiederaufbau
KUP	Karnali Ujyawlo Programme
kW	Kilo Watt
kWh	Kilo watt hour
kWp	Kilo Watt peak
LC	Letter of Credit
LEDs	Light Emitting Diode
LFIs	Local Financial Institutions
MHDF	Micro Hydro Depth Fund
MW	Mega Watt
MWDR	Mid-Western Development Region
NAST	Nepal Academy of Science and Technology
NEA	Nepal Electricity Authority
NEPQA	Nepal Photovoltaic Quality Assurance
NRREP	National Rural and Renewable Energy Programme
NRS	Nepali rupees
PIT	Product Introduction Test
PSEP	Pumimarang solar village electrification Project
PV	Photo voltaic

REF	Rural Energy Fund
REMO	Research and monitoring Software
RETS	Renewable Energy Testing Station
RETs	Renewable Energy Technologies
RMA	Rapid Market Appraisal
RSCs	Regional Service Centers
RST	Random sampling Test
SEMAN	Solar Electric Manufacturers' Association Nepal
SE4ALL	Sustainable Energy for all
SETM	Sustainable Energy and Technology Management
SETS	Solar Energy test station
SHS	Solar Home System
SNV	Netherlands Development Organisation
SPS	Solar PV Systems
SSHS	Small Solar Home System
ST	Solar Tukki
TWh	Tera Watt Hour
VAT	Value Added Tax
VDCs	Village Development Committee
WB	World Bank
Wp	Watt peak
WLED	White Light Emitting Diode
WTP	Willingness to Pay

Acknowledgement

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Preface

The market for solar lighting products has evolved tremendously over the past few years. Initiatives like Lighting Africa and Asia have exhibited the immense potential of the solar lighting market in Africa and South East Asia. This growing market has been typified by a very rapid sales growth, an increased preference for and availability of quality products, continued entry of new manufacturers and distributors, growing consumer awareness and confidence, remarkable improvements in performance, and innovation in business models.

Despite this success, penetration of solar Pico PV is still estimated at about 4 % of off-grid households in Africa, less than 5 % in developing Asia and in Nepal it is less than 40,000 deployments of solar Pico PV in last two decades. This scenario is leaving significant room for growth.

The market is currently constrained by several crucial and unresolved challenges. Chief among these are access to finance for manufacturers, importers and end-users, distribution of products to hard-to-reach customers in rural areas, and consumer awareness.

To identify the actual market scenario of the Solar Pico PV Market in Nepal, a dedicated study was necessary and this publication has been developed with that objective. Chapter 4 of this publication (Key Findings) presents the concise overview of the solar PicoPV market in Nepal, whereas chapter 2 and 3 discuss the current trends and future perspectives of the solar PicoPV market.

A key lesson is that the institutional setting of the project and the long-term commitment of the stakeholders are vital for the success of the solar Pico PV market. Researches on this

area reveal that (a) reliability and (b) appropriate sizing are the main challenges for PV-based rural electrification. Sizing PV systems for national electrification programmes is an important but also inherently difficult and often political process. The size of systems needs to be determined based on demand, which in turn needs to balance three often conflicting viewpoints, from: (i) international financial institutions, often oriented toward basic needs and cost-benefit analyses; (ii) end-users, who often list TV viewing as their highest priority; and (iii) engineers, who typically determine standardized need levels and system sizes. The convergence of these three viewpoints is vital for success [World Bank, Rural electrification in Africa, Washington D.C., USA, April 2012]. This publication has also investigated the commercial attractiveness of the solar Pico PV market in Nepal and found that given the multiplicity of products developing at all quality and price ranges, the market segment simply be considered as consumer products, offering a different perspective for their deployment. Indeed, to do this, the sector will need strong government support, readiness of financial institutions and market competition among the private sector actors in the solar domain! This is a dream, which needs to come true in Nepal!

1. INTRODUCTION

1.1 OFF-GRID LIGHTING-GLOBAL STATUS

Over one-quarter of the world's population lives without access to electricity and only 68 % of the global population has access to electricity (table 1). In South East Asia, approximately 227 million people do not have access to electricity, out of which the majority are dependent on kerosene and other fossil intensive sources of lighting (table 2).

SOURCE: IEA, World Energy, Outlook 2011

Table 1: Electricity access in 2009 - Regional aggregates

Population without electricity millions		Electrification rate %	Urban electrification rate %	Rural electrification rate %
Africa	587	41.8	68.8	25.0
North Africa	2	99.0	99.6	98.4
Sub-Saharan Africa	585	30.5	59.9	14.2
Developing Asia	675	81.0	94.0	73.2
China & East Asia	182	90.8	96.4	86.4
South Asia	493	68.5	89.5	59.9
Latin America	31	93.2	98.8	73.6
Middle East	21	89.0	98.5	71.8
Developing countries	1,314	74.7	90.6	63.2
World*	1,317	80.5	93.7	68.0

* World includes OECD and Eastern Europe

In fact, by 2030, World's un-electrified population is projected to grow to almost 1.26 Billion people (700 million people in Africa, or approximately 150 million households (figure 1) and another 561 million people in Asia. This means that, while the lighting need will be material all across the developing world, it will be greatest in South Asia and Africa in the coming years.

At the same time, new evidence on the negative health impact of using kerosene-based lighting products reiterates and

Table 2: Electricity access in 2009- Developing Asia

Afghanistan	15.5	23.8
Bangladesh	41.0	95.7
India	75.0	288.8
Nepal	43.6	16.5
pakistan	62.4	63.8
Srilanka	76.6	4.8
South Asia	68.5	493.4
Developing Asia	81.0	675.4

Source: IEA World Energy Outlook 2011

further bolsters the case for switching to cleaner alternatives like solar-based lighting products. A recent study by the Lawrence Berkeley National Laboratory of California's Lumina Project surveyed users of kerosene lighting across five Sub-Saharan Africa countries and found up to a fourth of the sampled population have health and safety concerns related to kerosene lighting . Insights from the study included:

- Kerosene combustion products are correlated with higher incidences of diseases like tuberculosis and cataract conditions. For example, researchers found the odds of having tuberculosis in Nepal were more than nine times greater for women using kerosene than those using electric light.
- Unintentional kerosene ingestion is the primary cause of child poisoning reported in most hospital studies. The consequences are severe, including mortality rates ranging from 0 % to 25 % for those visiting hospitals. In South Africa alone, almost 80,000 children in 3.6 % of all households unintentionally ingest kerosene every year. Almost 60 % of these children then develop chemically-induced

'Health impacts of fuel-based lighting,' Evan Mills, Lawrence Berkeley National Laboratory, University of California (2012). http://light.lbl.gov/pubs/tr/lumina-tr10-summary.html

Jacobson, A.; Lam N.L.; Bond, T.C.; Hultman, N. (2013) 'Black Carbon and Kerosene Lighting: An Opportunity for Rapid Action on Climate Change and Clean Energy for Development',

The Brookings Institute, Global Views #41. http://www.brookings.edu/research/papers/2013/04/climate-change-clean-energy-development-hultman

Lam, N. L.; Chen, Y.; Weyant, C.; Venkataraman, C.; Sadavarte, P.; Johnson, M. A.; Smith, K. R.; Brem, B. T.; Arineitwe, J.; Ellis, J. E.; Bond, T. C., (2012) 'Household Light Makes Global Heat:

High Black Carbon Emissions From Kerosene Wick Lamps', Environmental Science & Technology , 46, (24), 13531- 13538

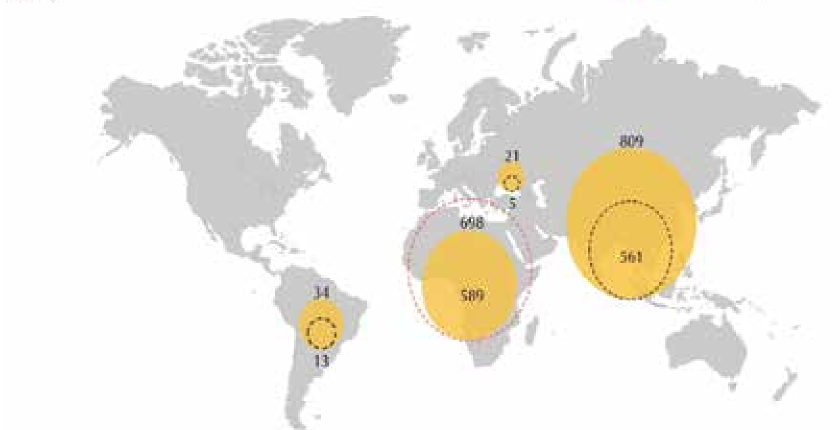
pneumonia.

- Fuel-based lighting is a significant cause of structural fires and severe burn injuries, with particularly high death rates (24 % on average) in cases where kerosene is adulterated with other fuels, resulting in explosions.

- Kerosene lighting also generates black carbon particulates that contribute to global climate change. Prior estimates of the climate impact of kerosene lighting that have focused exclusively on carbon dioxide emissions have understated the climate impact by a substantial margin. When black carbon emissions are considered, the climate impact is five to 15 times larger (Lam, et al., 2012; Jacobson, et al., 2013) .

Hence, concerted efforts are necessary to transform the current global scenario of poor access to electricity and off grid solar can play an effective role on this front.

Figure 1: Un-electrified populations across the world
Millions



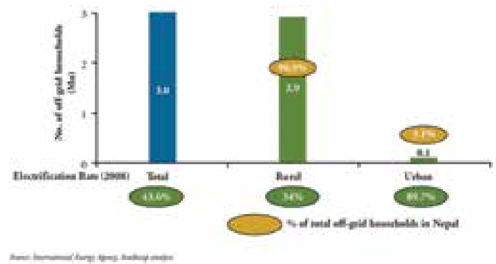
Source: Electricity Access Database (International Energy Agency); Dalberg analysis

Energy Situation in Nepal

Nepal is a landlocked Himalayan country with an area of 147,181 km^2 and a population of 28.6 million . It is a Least Developed Country (LDC) with a Human Development Index (HDI) of 0.428 and per capita nominal GDP of USD 642. Total energy consumption in Nepal in the year 2009-10 was about 9.4 million tonnes of oil equivalent (401 million GJ) of which some 87 % was derived from traditional resources such as wood biomass and animal waste, 1 % from small renewable energy sources, and only 12 % from hydropower plants and commercial energy sources such as petroleum and fuel products. Petroleum products, which account for about 8 % of the total energy consumed, require one third of the foreign exchange earnings to import.

Electricity represents only 2 % of the total energy consumption in 2011-12. In the residential sector, biomass contributes about 96 % of the total energy consumed. The shortage of power and frequent power outages has severely constrained the growth potential of the country. Nepal's power generation capacity of 706 MW, which is predominantly hydropower, is insufficient to meet growing demand and has led to over 14 hours of load-shedding a day during winter (low river flow) season. Nepal, which built its first hydropower plant in 1911, has an estimated technically feasible hydropower potential of 42,000 MW, much of which is yet to be developed.

Figure: 2-Rural-urban distribution of off-grid households



Electricity access. 56 % of households (HHs) in the country have access to electricity (including off-grid solutions) . On the other hand, 33 % of households still depend on kerosene for lighting and only 2,100 out of Nepal's 3,915 village development committees (VDCs) are connected to the national grid). Almost

all (99.7 %) HHs in the urban areas of Kathmandu valley have access to electricity. Among five administratively defined development regions , the Western development region has the highest proportion of households using electricity (63 %), while the Mid-western development region has the lowest (34 %). By ecological regions, the Mountains have the least proportion of households that use electricity (41 %).

The proportion of households using electricity in the Hills (56 %) and Terai (59 %) are slightly higher. As to be expected, urban areas have better access to electricity relative to rural areas (93 % versus 49 %) .

Current state of Off-grid lighting in Nepal:

According to the findings of the IFC report on Lighting Asia, there are 3 million off-grid households in Nepal, the majority (approx. 97 %) of which is in rural areas. The report has also stated that the electrification rate in rural Nepal is as low as 34 % (in 2008) compared to the national average of 44 % and for lighting, households (off-grid as well as under-electrified) use kerosene lamps, constituting another major source of indoor air pollution and greenhouse gas (GHG) emissions. Nepali households consume approximately 0.024 litres of kerosene per hour or 3.6 litres of kerosene per household and per month . The approximate monthly expenditure per household for kerosene is 2.1 Euro, at times going up to double that amount (with kerosene prices reaching 1.5 Euro per litre in these remote regions of Nepal). Hence, the current household expenditure for having access to cooking and lighting is approximately 9.4 Euro per month (13 % of rural household expenditure).

Study Rationale:

In this context, accessing solar lanterns as a clean lighting energy solution is an interesting offering for these rural poor. The approximate market potential of solar lighting solutions in Nepal amounts to 3.6 million households, constituting a market worth 47 to 50 million Euro . Demand for quality products is there, yet they are not available to the people who need them. There is increasing private sector

appetite to get involved in this market. This involvement however, is constrained by the lack of capital, poor access to lending portfolio of financial institutions and absence of a well-defined supply chain of solar lighting in general and solar PicoPV in particular. Hence, it is imperative to establish a baseline and a detailed market study of the solar pico PV market in Nepal to gather the following information:

- Access to lighting Energy supply and consumption patterns for household lighting
- Lighting options/technologies available
- Level of awareness about the lighting technologies/options
- Affordability /Willingness to pay for lighting
- Availability of financing options
- Mapping of Pico PV (small solar PV system) distributors/suppliers/service providers

1.2 OUTPUTS

The study intended to establish Pico PV baselines at three different levels:

I. Household Level Baseline: ground level scenario to capture access to lighting, energy supply scenario, energy consumption patterns, level of awareness about the lighting technologies and options that are available in the far western and mid-western regions of Nepal.

II. Socio-Economic Level Baseline: to have insights and evidences of socio-economic impacts of the new lighting devices on the users/households; affordability, ability to pay and willingness to pay for lighting sources among different income level people. Economic baseline also included consumption patterns for household lighting and its expenditure in energy the rural Nepal.

III. Distribution Level Baseline: this baseline provided information on different lighting options and technologies available in the study district. It also detailed mapping

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IFC Report on Lighting Asia, 2012

SNV Baseline study for Solar PicoPV, 2014

of Pico PV distributors, suppliers and service providers in the far western and mid-western region of Nepal. Additionally, an assessment of availability of financing options to develop financing models of the existing methods of provision of lighting and small appliance charging services and products, from traditional and renewable energy sources has been done.

1.3 STUDY METHODOLOGY

The study was conducted applying the Rapid Market Appraisal (RMA) and Value Chain Analysis (in case of domestic supply chain of pico-PV). A mix of qualitative and quantitative data types were researched and analyzed based on existing data available and understanding of the market.

The study has collected three different data sets: primary data, secondary data and tertiary data.

Primary Data were largely quantitative and were collected through questionnaires. This information was collected from household survey and pico-PV sellers (retailers/ distributors).

Secondary data were collected during focus group discussions and consultative meetings with various stakeholders.

Tertiary data were obtained from literature reviews of relevant studies/documents in Nepal and similar studies in other countries (publications of SNV, IFC, GIZ, etc.) to get useful information for analysis.

Four study teams comprising an engineer and a socio-economist conducted the baseline study using detailed questionnaires/checklists for household and consultative meetings. To ease HH survey, Research and Monitoring Software (REMO) was used.

REMO is the first ICT product of Rooster Logic which has been developed to innovate the registration and survey process for an Organisation. The software runs on a smartphone that has a capability to capture all the required data along with photographs, GPS triangulation of the location which makes the data usable for validation, verification and adds on to the pragmatic approach of reporting.

The baseline study was conducted in 7 districts in Far Western DR (Dadeldhura, Doti, Baithadi, Bajhang, Drchula, Bajura and Accham) and 2 districts of Mid-Western DR(Surkhet and Dailekh)

To analyze and develop an appropriate pico PV business model, a mapping of domestic business and existing distribution chains in the selected nine districts was undertaken. The study team interacted with central level manufacturers, distributors, retailers, agents and gathered information about the type of lighting devices that are used, user's preferences in selecting the lighting devices, major complaints from the users, major limitations for expansion of their business etc. The survey team also consulted with banks and other financing institutions both at the central and district level to get inside information about the available financing options, their landing priorities and willingness to engage in the sector. The team organized meeting with regional solar PV distributors and obtained required information for supply side market analysis. At all stages of the study, a series of interactions with SNV-Nepal were conducted. Similarly, a stakeholders' consultation was organized to share the study findings. Inputs/feedbacks from all these interactions were incorporated in the final report.

1.4 STUDY LIMITATIONS

The following were the limitations of this study.

1. The study was focused on establishing a baseline of pico PV (10 Wp and below) based on the survey in the clustered areas of far western and mid-western regions of Nepal. Therefore it cannot be considered as a national baseline for this technology.

2. A stated performance approach was applied to measure hypothetical Willingness to Pay (WTP) of rural households for different solar products. The proposed sample of 100 households does not necessary reflect the exact situation of the pico PV market.

3. Significant part of the report relied on secondary information and direct inputs from experts, which do not necessarily reflect the real situation.


VOLTA

2. SOLAR OFF-GRID LIGHTING MARKET IN NEPAL: OVERVIEW

2.1 LIGHTING ENERGY SUPPLY & DEMAND SCENARIO

2.1.1 Demand Scenario

National Population Census 2011 of Nepal (CBS, 2012) exhibits that electricity has reached 74 % of the Nepali population; 94 % of urban population and 70 % of the rural population. Taking CBS as a reference point, in total 1.37 million people (26 % of total households) still do not have access to electricity and currently rely on traditional lighting sources.

Table 3: Electrification Status in Nepal

	Estern	Central	Western	Mid Western	Far Western
Electrified HHs	872,182	1,576,078,	879,408	433,198	290,384
Not electrified HHs	358,561	386,160	186,191	261,816	179,319
Total HHs	1,230,743	1,962,238	1,065,599	695,014	469,703

Source: CBS, 2012

The possible future sources of their electrification could be large hydro (grid), solar home systems or stand-alone mini grids. Out of the non-electrified households, the majority use kerosene in eastern, central and western development regions. In the mid and far western development regions, people use jharoo and other sources to meet their daily lighting requirement.

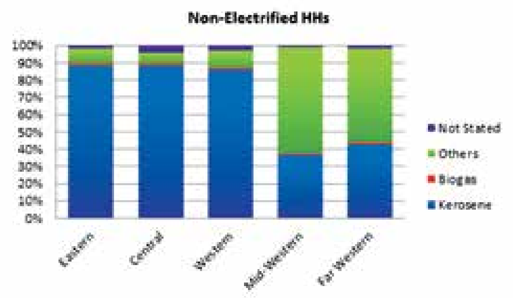


Figure 3: Details of non-electrified households

Regardless of the access to electricity, the quality of electricity supply has always been questionable. For small number of urban customers, average electricity supply is less than eight hours per day, with load shedding accounting for up to 16 hours during winter. A national electricity crisis of unprecedented severity, due to droughts and technical delinquencies for many years, has brought underinvestment and sharp growth in electricity demand. Other recent studies have concluded that Nepal has strikingly low levels of access and electricity consumption

compared to many other developing countries.

Solar PV with numerous advantages is the most appropriate technology for Nepalese rural families where the NEA grid and micro hydro are not feasible. Additionally, not reliable grid services (severe load shedding) increase the demand for solar backups even in urban areas.

2.1.2 Supply Scenario

Among 4.05 million electrified households (74 % of total households), 80 % are connected to the national grid, 10 % are consumers of mini/micro hydro and the rest (10 %) have Solar PV Systems. NEA Grid coverage is highest in central development

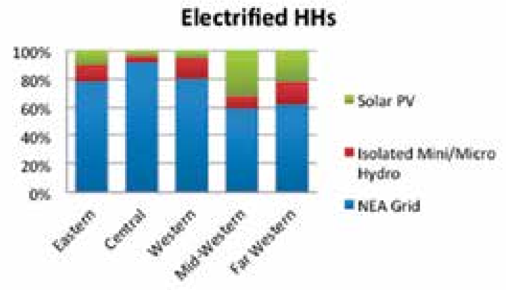


Figure 4: Details of electrified households

region. The maximum number of solar systems are installed in mid-western development region.

The state owned Nepalese Electricity Authority (NEA) is responsible for the electricity supply through the national grid.

Beside the national grid, numerous mini hydro plants are operational in many district headquarters. Thousands of small installations (diesel gen-sets, solar home systems, small island mini grids etc.) are installed in urban Nepal. Off-grid isolated system are mainly regulated and implemented by Alternative Energy Promotion Center (AEPC). The electricity supply from off-grid hydropower plants in rural area is limited to an average of about 150 watts per household and is used mostly for lighting, charging mobile phones, and powering small equipment and appliances. Electricity from solar PV home systems is even more limited, to an average of about 20-25 watts per household.

2.2 SOLAR LIGHTING POTENTIAL

The average solar radiation in Nepal varies from 3.6 to 6.2 kWh/m2/day . With more than 300 sunny days, Nepal receives around 4.7 kWh/m2/day of solar energy at optimum tilt. It has abundant solar energy resources evenly distributed over the country and over the seasons. The monthly daily global solar radiation varies from 120 to 260 W/m2 with the annual sun shine duration ranging from 1,900 to 2,500 hours.

The commercial potential of solar power for grid connection in Nepal is estimated as 2,100 MW (SWERA , 2008).

Around 2,920 GWh of energy per year can be harnessed with utilization of just 0.01percent of the total land area of Nepal from the solar energy.

SE4ALL's Rapid Assessment and Gap Analysis Report, projected scenario indicates that hydropower plant capacity development needed will be 5,600 MW and 14,000 MW in 2020 and 2030 respectively with a 25 % reserve for the peak power demand. Distributed generation of off-grid and isolated electricity with micro, pico hydro and SHS is expected to be 60 MW and 220 MW by 2020 and 2030 respectively. Solar PV power plants are becoming most competitive with declining prices of solar PV modules in international markets (IRENA, 2012) and it is expected that around 100 MW and 2,100 MW grid connected solar PV plants will be installed by 2020 and 2030 in Nepal. NEA is in the process of installing 20 MW PV power plant currently in 2013.

2.2.1 Market Potential of Solar PV

With 1.37 million households beyond the access of clean lighting and no grid connection for years to come, other off grid systems including Solar PV could be a viable option.

One of the approaches to estimate the total market potential for solar lighting energy in Nepal could be the multiplication of total market size in terms of households with an average cost of solar home systems .

"Energy Sector Synopsis Report Nepal 2010" by Water and Energy Commission Secretariat (WECS)

Study conducted by AEPC, 2008 under Solar & Wind Energy Resource Assessment in Nepal (SWERA)

The most popular size of 20Wp system is considered

It cannot be assumed in reality that total market potential represents 100 % market penetration. Therefore the study expects 50 % of the market will be served. Therefore, a total of 8,220 million Nepali Rupees (approximately 62 million EUR) will be required.

Among them, there is a large portion of HHs who are in need of electricity but are merely left out as they cannot pay any upfront cost to install the solar home system.

It's been more than a decade that the government solar subsidy program is operational but it has not been able to incorporate the population referred to as "Poorest of the poor". The left out population is still significant in numbers, could be a potential market for small solar home system (picoPV) if some enabling environment can be established. A good package of awareness messages, along with workable loan products will help to increase the installation of SSHS in rural areas.

2.3 GON'S THREE YEAR PLAN

The recent objective of achieving universal access to modern energy by 2030 has paramount importance for a developing country like Nepal. For this purpose, the current Three Year Plan (2013 - 2016) has identified hydropower and other energy development as one of the priority areas and envisions upgrading Nepal from least developed country to developing country status by 2022. With increase in access of reliable and quality electricity through hydropower promotion, the plan seeks to reduce dependence on traditional fuels and increase electricity access to population living far away from the national grid through off-grid renewable energy systems. It further targets addition of 665 MW of hydroelectricity and ensuring electricity access to 87 % of the population. With the objective of achieving per capita electricity consumption of 140 kWh it also targets to add 15 MW of off-grid hydro, 6 MW of solar electricity and 1 MW of wind energy, providing electricity access to an additional 7 % of the rural population.

2.4 SOLAR PHOTOVOLTAIC (PV) SYSTEM

Solar energy was first conceived as viable alternative form of power as early as the 1860s when coal was expected to be running out of supply. However, due to the abundance of coal and petroleum, no major progress was made in solar technologies until the global oil crisis of 1973. The crisis brought renewed attention to the potential of solar power as alternative source of energy. In response, industrial countries made a concerted effort to develop solar power technologies by creating and maintaining well-funded research and development agencies. As a consequence, photovoltaic installation rapidly increased in the late 1970s and 1980s. With increasing evidence of the global warming in the 1990s, solar energy was seen to be one of the most viable sources of energy to replace carbon emitting fossil fuels and thus became more mainstream technological solutions in response to the energy crisis.

Over the last decade only Solar PV generation expanded by 50 % per year worldwide, reaching almost 100 TWh in 2012 (IEA, World Energy Outlook, 2013). Many countries have made solar energy a central part of their energy policy and committed to fulfill a substantial portion of their energy demand from solar power. Only in the last year, the total installed capacity of solar PV increased by 43 %, or 29.4 GW, which represents 15 % of the total growth in global power generation capacity (IEA, World Energy Outlook, 2013). Countries like Germany (7.6 GW), Italy (3.6 GW), China (3.5 GW), Japan (3.3 GW) and India (1.1 GW) accounted for a major portion of the global installed capacity of solar PV under the impetus of strong government support. It is interesting to note that in most countries, government supported programs and subsidies have driven the growth of solar. But with the rise in global installation units, the cost of producing electricity from solar PV has fallen dramatically over the last decade, leading to a debate whether they are now competitive, without subsidies.

2.4.1. Understanding The Solar Pico-PV Product Range

The industry today lacks a common set of definitions or terminology with solar lanterns being too generic a term to properly define the spectrum of products available . In addition, it is believed that consumers select products primarily based on price. Due to this reality, a broad proliferation of product categories is currently widely used, but the following styles of products are increasingly available in the market:

Flashlights/Torches - portable handheld devices offering directional lighting at low lumen output. Today's solar torches typically feature integrated solar panels.

Task lamps/work lights – portable or stationary handheld devices, including

solar desk lamps, in a range of panel sizes and light output levels utilized for specific tasks (i.e. reading, weaving etc.).

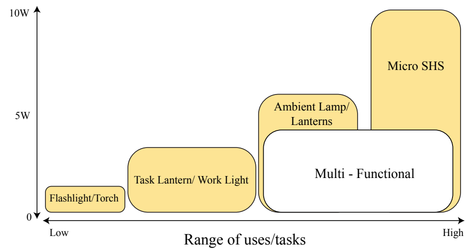
Ambient lamps / "lanterns" – portable or stationary devices that resemble the kerosene hurricane lamp form factor. They typically offer multi-directional light along with a wide variety of size and functionality depending on technology (e.g., from heavy powerful CFL lanterns to smaller LED-based systems)

Multi-functional devices – portable or stationary devices that can provide directional and multi directional light, a variety of value added features (i.e. mobile phone recharge), and can be utilized for either task based or ambient lighting needs.

Micro-SHS – semi-portable lighting devices associated with a small portable solar panel that power or charge 1-3 small lights, mobile phones, and other low power accessories (e.g., radio, mini-fan).

These products are distributed across a spectrum of decreasing specialization and increasing lumen output, which correlates directly with increasing capacity of the solar panel typically attached to them (Figure 5).

figure 5: Scope: Portable Lights (PSL)

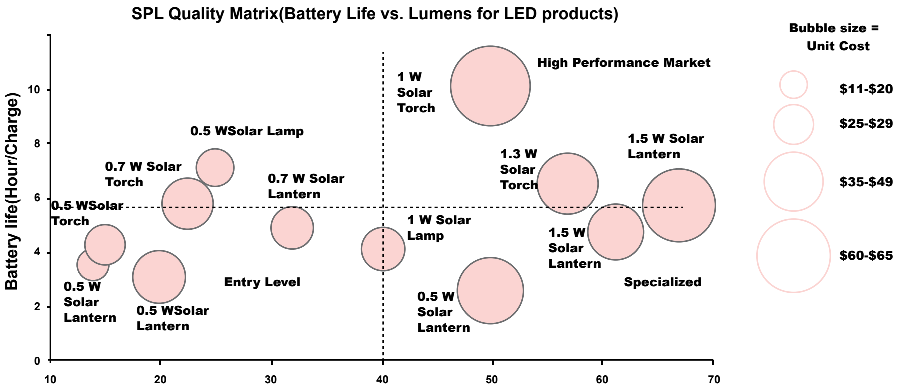


Source: Delberg analysis

As IFC has highlighted in the report on Base of the Pyramid- Overview of an Emerging Market; the core characteristic of a lighting product remains its ability to deliver bright light, for a long enough period of time at an affordable cost. However, the ability to deliver a high level of lumen output is in direct competition with battery life. And, both high battery life and high luminosity are associated with higher prices.

Hence, the use of a Solar Portable Light Performance Matrix is important while identifying Solar PicoPV products. This matrix demonstrates the range of performance witnessed in the market, based on independent testing and the latest price associated with such products (Figure 6). It can be clearly found in the matrix that there is correlation between price

Broad spectrum of product performance emerging



Significant outliers exist in independently tested data which have been omitted pending further analysis

Source: REEEP, Lawrence Beridey National Laboratory

and performance, there are also clear price leaders in each segment, even within our small sample set.

It is worth noting that the bottom end of the solar lantern market contains many products that fail to meet minimal quality requirements. This is especially true for many South Asia and African markets, already leading to problems of market spoilage. Therefore this study omits low cost, low quality products in all analyses – primarily rechargeable LED torches in the $1-10 range.

2.5 SOLAR PV DEVELOPMENT TREND IN NEPAL

The context for the use of solar power in Nepal is slightly different. The power deficit in the urban areas of the country (load shedding) and lack of access to national grid in rural Nepal has increased the demand for solar PV. The present cumulative number of SHS systems promoted all over the country is 410,430 and has a total installed capacity of 9,915 kWp. It is believed that about 8 % of the country's population has been using the solar PV as their primary source of light energy.

History of solar can be traced back to the 60s when for the first time solar was introduced by Nepal Telecommunication Corporation to operate transceivers. With this it was further used in public services like offices of civil aviation and traffic lights.

The first Solar PV system for domestic lighting was installed in 1993 with the support from SELF/USA . These Solar Home Systems (SHS), which includes each system of 36 W PV panel, 70 Ah battery and 10 W tube light were installed at 48 HHs in the Pulimarang Village of Tanahu district.

Centralized electricity supply from solar PV was initiated only in 1988 when Nepal Electricity Authority (NEA), with the assistance from the French government, installed centralized solar PV power system in three locations: Simikot (50 kWp) in 1988, Kodari/Tatopani (30 kWp) and Gumgadhi (50 kWp) in 1989 (CRE, 2003). Unfortunately, none of the systems are in operation today.

SELF/USA: US based company working in LED display and accent lighting innovation, design, and production.

Global drivers of off-grid lighting market growth

Globally, the five major drivers of demand for off-grid lighting are:

1. Lagging grid growth: the importance of grid growth as a driver for SPL demand varies by region, with rapid grid growth likely in select Asian and Latin American geographies and very slow grid growth seen in many African nations. Grid penetration typically needs to grow by over 2-4 % a year to counteract the effect of population growth – in practice this means that even substantial investments into the grid will leave many large nations with sizeable and growing off-grid populations in decades to come.

2. Price trends: rapid technological innovation in basic SPL technologies and a scale-up of commercialization efforts by lighting entrepreneurs is driving a substantial decrease in the manufactured price of solar portable lights, and since affordability is arguably the main obstacle to market adoption, falling manufacturing costs and corresponding declines in the retail product price will be a critical driver of demand going forward.

3. Technology and design innovation: Beyond improvements in price, the top of the SPL market is also undergoing a revolution in product design and quality. Most manufacturers have not yet achieved the quality and reliability standards of mass produced consumer electronics, but the market is starting to see a number of products combining sufficient quality of build, long battery life, and most important, value-added features and product designs that address the particular needs of BOP off-grid and under-electrified consumers. Innovation is set to accelerate as technological components fall in price and entrepreneurs invest more resources into studying local conditions and end-users.

4. Kerosene prices: kerosene, the main traditional alternative to off-grid renewable lighting, has long been an expensive commodity for the poor and is expected to continue increasing in price. Analysts forecast an average increase of 4 % annually over the next five years. This combined with increasing pressure on kerosene subsidies in Asia and Africa, will drive consumer demand for cheaper alternatives.

5. Mobile opportunity: Today, nearly 500 million people worldwide (i.e., a third of the 1.6 billion off-grid population) have a mobile phone subscription but no easy or cheap access to a means of charging their phones. A number of potential charging solutions are on the market, but if lighting manufacturers take advantage of this trend (e.g., partnerships with phone companies, mainstreaming of mobile charging functionality), the mobile opportunity could become a major driver for SPL sales globally – providing a value proposition to both consumers who can avoid mobile phone charging costs and to the phone companies who can sell more airtime.

2.6 TECHNOLOGY SNAPSHOTS

Solar PV technology is widely used for domestic applications (lighting, mobile charging, powering radio/TV, etc). Besides that, large scale systems are basically used in schools, hospitals, industries and rural enterprises located in off-grid area. Solar PV Pumping Systems are also a comparatively new product in Nepalese market.

Solar Lanterns are commonly available in the Nepalese market. These systems are more popular in urban areas and used as a back-up tool to cope with the long power cuts in the grid connected households.

Small Solar Home Systems (SSHS) are the appropriate lighting sources for the poorest of the poor segment of the rural areas that are sufficient to address daily lighting energy demand. Likewise, the Solar Home Systems (SHS) are now commonly used for operating wide ranges of basic appliances along with lighting, as TV, charging of mobiles among rural households. The 20 Wp SHS being the most popular system. More details on these technologies are briefly described below:

Table 4: Brief on different solar lighting options

 **Solar Lanterns *(1 Wp to 2.5 Wp)***	 **Small Solar Home System *(2.5 Wp to 10 Wp)***	 **Solar Home System (*More than 10 Wp*)**
	General Features	
• Comparatively new and widely available in Nepalese market • A portable light fixture composed of a LED or CFL lamp, a photovoltaic solar panel and a rechargeable battery. • Not for mobile charging and running radio/TV. • Various models from D. Light Design are available in the Nepalese market; S2, S20 and S300 • Alternative to kerosene lamps in rural settings and backup to load shedding in urban areas.	• Commonly known as Solar Tuki • Integrated system consisting of battery, charge controlling mechanism and appropriate number of DC or WLED lights. • 5 Wp systems have single socket for radio with at least 2 lights each of 1.5 W for 4hrs. • 10 Wp system have facility to use 3 LED lights and ports for mobile charging and small radio. • Rural households with small families and backup to load shedding in urban areas	• Integrated system consisting of battery, charge controller and an appropriate number of DC lights. • In rural households commonly used 20 Wp and 40 Wp. • With a 20 Wp system, the users have a facility to use CFL lights of 3 W each and/or LED lights of 1.5W each. Mobile charging and power outlet for radio are available • With a 40 Wp System, the user have facility to use 6 LED lights, mobile charging, radio and power for B/W TV. • Both rural and urban areas.
	Investment	
Total Cost : USD 9.5 to USD 33 Subsidy: no subsidy	Total Cost: USD 67 Subsidy: USD 45 to USD 50	Total Cost : USD 163 to USD 364 Subsidy: USD 60 to USD 100

2.7 CURRENT SATUS OF SOLAR PV DEVELOPMENT IN NEPAL

2.7.1 Solar Home System (SHS)

Massive promotion of SHS started in early 2000's with around 2000 systems. As a result of Energy Sector Assistance Program ESAP-I (1999-2007) and ESAP II (2007-2012) initiatives, about 91 thousand SHS were installed with a total capacity of 2,007 kWp. The present cumulative number of Solar PV systems promoted all over country is 410,430 and has a total installed capacity of 9,914 kWp (AEPC, 2014). It is believed that about 15 to 20 % of the total installation was taken place out of the GON's subsidy support.

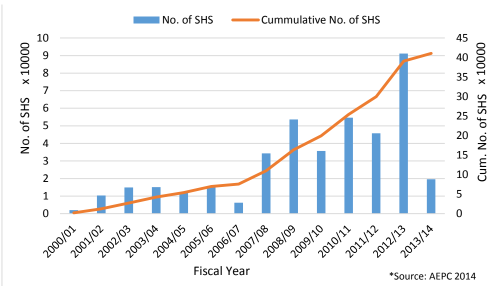


Figure 7: annual SHS Installation

Regional Distribution of SHS

Highest number of SHS is installed in the Mid-western Development Region (164,752) followed by Far Western Development Region (64,656). The same trend is followed in Eastern and Central Development regions (CDR). In Western Development Region, only 59,278 systems have been installed.

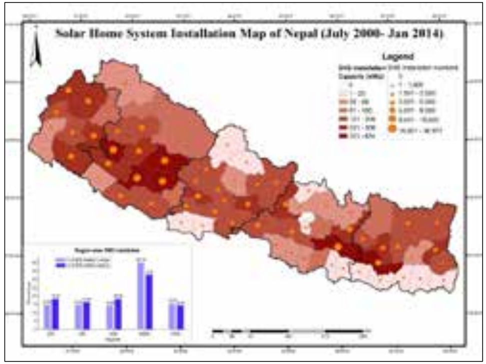


Figure 8: regional distribution of SHS

2.7.2 Small Solar Home System (SSHS)/Pico PV

Before 2012, the AEPC was promoting 5 Wp systems, which was then realized to be not appropriate to meet the demand

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ESAP II was initiated in 2007 and completed in july 15,2012.

of rural households. In 2012, AEPC has introduced 10 Wp system with 3 bulbs and mobile charging devices. Furthermore, AEPC has revised subsidy policy and its delivery mechanism for effective dissemination. As of now (January 2014), the total cumulative number of installed SSHS reached more than 27,000 with a total installed capacity of 135.49 kWp.

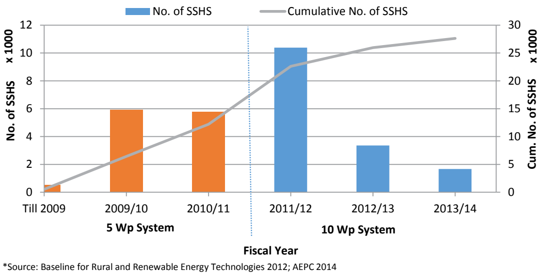

Figure 9: annual SSHS installation

The small solar home system (SSHS) is normally targeted to the poorest segment of the rural population. Unlike the solar home system, the SSHS installation numbers in the last two years were not so promising. The long subsidy disbursement process of AEPC and uncertain forecast from different programs has discouraged the solar companies to promote SSHS.

Central Development Region has the highest number of SSHS (8,710), followed by Far Western Development Region. Eastern Development Region has the least number of SSHS installed (2,468).

It is very interesting to find that small solar

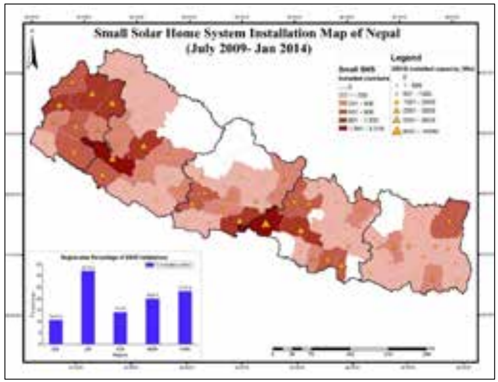

Figure 10: Regional Distribution of SSHS

home systems (SSHS) which are targeted to the poorest segment of the rural population have a higher distribution in CDR than other

regions of Nepal. From the field survey, it was observed that the supply of these smaller systems was found relatively low in the mid and far western development region in spite of its huge demand.

2.7.3 Solar Tuki

The Government of Nepal (GoN) has launched the special programme called "Karnali Ujjyalo Programme" (KUP) in 2007 to enable the people in Karnali zone and its adjoining districts to purchase the Solar Tuki. Under this programme, GON through AEPC has installed (distributed) 31,000 Small Solar Home System (SSHS) called "Solar Tuki" (ST) in five districts of Karnali zone and 29,000 in four adjoining districts (Jajarkot, Bajhang, Achham and Bajura) . The main objective of the program was to provide immediate solution of lighting energy for the poor households residing in the said districts having similar poverty level. Almost 95 % of the cost of ST (Unit Price Rs. 4,500) was subsidized by the GoN and the remaining amount was paid by the users. The small solar PV system promoted consisted of a 5 Wp solar module, a battery box with switches and indicators, two units of WLED based lamps and wiring accessories. The lamps were plug-in types that could be hanged on any place with the support of attached hook. The success of the Karnali Ujalyo Program is unknown as the quality of the product and delivery modality are heavily debated. While surveying in some of the districts, none of the ST distributed under that programme were found in the houses.

2.8 PRICING TREND OF SOLAR LIGHTS IN NEPAL

In the Nepalese market, widely customized SHS packages are available. Normally under the subsidy scheme, the system capacity varies from 10 Wp (SHHS) to 50 Wp, however based on AEPC database, 85 % of the SHS installations are of 20 Wp systems. The quality of different components, branding of manufacturers, warranty/guarantee and after sales services provisions are the key factors to determine the system price at the wholesaler level. It was observed that the system price for the same capacity system varies. At the dealer/

retailer level, other costs like transportation, their overhead and other risk mitigation costs are added. Therefore, the system price at the end user level varies widely and could not be obtained. However, the study team has calculated the year wise average cost of 20 and 40 Wp SHS and 5 Wp and 10 Wp SSHS using the costs stated in the Proforma invoices submitted by the pre-qualified companies in Rural Energy Fund (REF) of AEPC. Surveys of few companies were made randomly to support calculation of the cost of services.

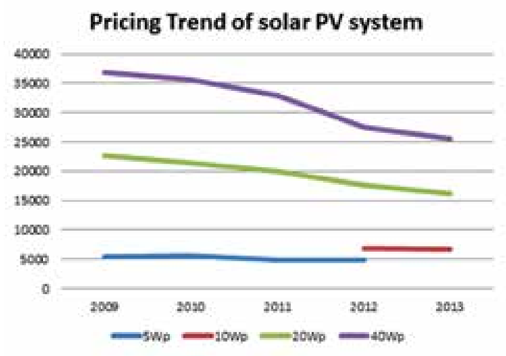

Figure 11: Pricing trend of Solar PV system

Over the last few years, the price of solar PV systems has significantly reduced in the international market. In the Nepalese context, where the majority of the solar PV systems are sold under the GON's subsidy scheme, the average price of 20 Wp and 40 Wp systems were found reduced by 28 % and 30 % respectively in the last 5 years. Figure 8 presents the average cost paid by the end uses of the solar PV.

2.9 CONSUMERS PREFERENCES AND PRODUCT VARIATIONS

2.9.1 Consumer Preferences

The Solar PV market has experienced significant development in the last few years and more efficient solar PV systems with more choices (in terms of size and quality) entered the market. With increasing technical advancement and economic prosperity, people's preference has been shifted towards bigger size system. Users in most cases prefer to install a cost-effective system that meets their daily lighting energy requirement .

The average cost presented in the figure is the sum of the average cost of all solar accessories (Solar panel, Battery, Charge Controller and Lamps). The average price is cumulative of subsidy amount and remaining amount to be paid by users. The PQ solar installation companies install SHS in users' houses, get filled up the subsidy application form and deduct from the system price. AEPC/CREF reimburses the subsidy amount to the installation companies once the application is submitted/approved.

Quality, warranty/guarantee and after sales services, are not much of concerns to rural users; in general they are more worried about the upfront investment.

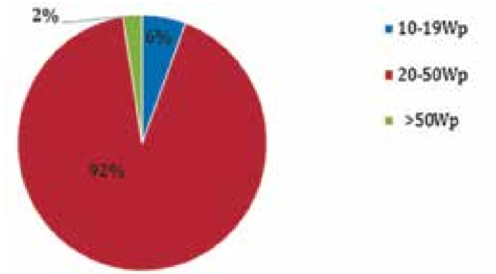

Figure 12: Size-wise distribution of solar PV system

2.9.2 Product System Design

There is no specific rule/procedure to assemble the solar PV system. As far as the technical specifications (size) of its components are concerned, all the PQ companies should follow the NEPQA guidelines. Normally the wholesalers import separate components and assemble in different packages with different quality and price variations. Dealers/retailers prefer to buy the same assembled sets at negotiated price from the wholesaler/importers and sell to the consumers. Depending on the market situation, dealers/retailers can also buy separate components from the wholesaler, assemble them and sell to the users as per their demand.

2.9.3 Solar PV Product Variations

There is a variety of solar products available in the Nepalese market. There are more than 180 different types of solar panels (from 44 manufacturers world wide) available in the market with capacities ranging from 10 Wp to 260 Wp. More than 25 local PQ companies are directly engaged to import those products to the Nepalese market. Batteries are either imported or locally assembled. As of today, 10 different types of batteries from 4 manufacturing companies are available in the local market. 10 local PQ companies are engaged in importing the batteries (mainly from India and Bangladesh). Similarly, 18 types of charge controllers from 10 different companies have entered to the local market. They are of 3 to 60 A capacity and are imported by 10 different local companies. Numerous lamps with wide varieties of size

and types are used in solar lighting. Most of the bulbs are White LED (WLED) from USA/ Germany based manufacturers from 2 to 6 watt load (RETS, 2014).

2.10 MAJOR PLAYERS IN SOLAR PV SECTOR

2.10.1 Alternative Energy Promotion Centre

The Alternative Energy Promotion Centre (AEPC) is a Government institution established on November 3, 1996 with the objective of developing and promoting renewable/alternative energy technologies in Nepal under the Ministry of Science, Technology and Environment (MoSTE). It is working as a national focal agency of alternative/renewable energy in Nepal. AEPC functions independently, and has an eleven member's board with representatives from government sector, private sector and non-governmental Organisations. The mission of the AEPC is to make renewable energy mainstream resource through increased access, knowledge and adaptability. In addition, it is an institution recognized as a regional/international example of promoting large-scale use of sustainable renewable energy.

AEPC is working in all 75 Districts of Nepal. AEPC has been executing various donor funded renewable energy programs/projects including the National Rural and Renewable Energy Program (NRREP).

2.10.2 Energy Sector Assistance Program

Energy Sector Assistance Program (ESAP) launched in 1999 was one of the programmes overseen by AEPC with the technical and financial support of Government of Denmark (DANIDA), Government of Norway and kfW, Germany. The Major objective of ESAP was to "achieve sustainability in the rural/renewable energy section in Nepal" (AEPC, 2011). ESAP comprised of different technical components, including the solar energy component. For the first time, GON has introduced subsidy support for Solar Home System (SHS) under the ESAP-I. During the ESAP first phase (1999-2007), 75,714 SHSs were installed. Under the second phase of ESAP (2007-2012), all together 269,548 SHS and 24,283

SSHS were installed against the target of 250,000 solar home systems and 50,000 small solar home systems.

2.10.3 Renewable Energy Project

The Renewable Energy Project (REP) was supported by the EU and implemented by AEPC from August 2004 to August 2012. The project supported the installation of solar energy systems, owned and managed by the Community Energy Service Providers (CESPs), for public institutions such as schools (for powering computers, printers, photo copier, lighting etc.), health posts (for vaccine refrigeration, medical lamps etc.); and rural communities (for water pumping, milling agro-grains, communications, literacy classes, entertainment etc.).
Under the project of a total of 933 solar PV systems with a total generation capacity of 1.023 megawatt peak has been installed in 21 remote districts of Nepal. The installed PV systems are for: 378 schools, 206 health posts, 29 computer literacy classes, 59 community entertainments centers, 124 community communication centers, 107 agro-grinding mills and 30 water pumping systems. Similarly, the project has also supported the installation of 24 solar dryers and 14 solar hot water systems.

2.10.4 National Rural and Renewable Energy Programme (NRREP)

AEPC has started execution of National Rural and Renewable Energy Programme (NRREP) from16 July 2012. A consortium of five governments (Nepal, Denmark, Norway, Germany and United Kingdom), two multilateral banks (ADB and WB) and three international Organisations (UNDP, UNCDF and SNV) have committed a total fund of 184 million USD to execute this five year program. The development objective of NRREP is to improve the living standard of rural women and men, increase employment of women and men, reduce dependency on traditional energy and attain sustainable development through integrating the alternative energy with the socioeconomic activities of women and men in rural communities. One of the key targets of this program is to support 600,000 households

with small/solar home system. As of now, 65,168 SHS and 3350 SSHS were installed across the country.

2.10.5 Renewable Energy Testing Station (RETS)

For quality assurance and standardization of various renewable energy technologies under the GON's subsidy program, Renewable Energy Test Station (RETS) was established as an autonomous body governed by "RENEWABLE ENERGY TEST STATION RULES 2063" framed under Nepal Academy of Science and Technology (NAST). Previously it was known as Solar Energy Test Station (SETS). It mainly carries out laboratory tests of various components in compliance with the Nepal Photovoltaic Quality Assurance (NEPQA) of solar system components.

This technical standard for components of Solar Photovoltaic Systems was first developed and adopted by AEPC/ESAP in December 2000 for dissemination of SHS under ESAP. The NEPQA revised in 2013 specifies the documents and technical requirements of the components used in PV applications, i.e. Solar Home Systems (SHS), Small Solar Home Systems (SSHS) and Institutional PV applications, institutional pumping PV system etc. Under the NEPQA guideline, the RETS conducts two tests: Product Introduction Test (PIT) and Random Sampling Test (RST).

2.10.6 Solar Electric Manufacturing Association Nepal (SEMAN)

The Solar Electric Manufacturing Association Nepal represents the entire Solar PV Electric Industry in Nepal. The major objectives of SEMAN are to work as an umbrella Organisation of the companies working in solar PV sector to protect, develop and professionalize all its members. In addition, in rural Nepal, it encourages the establishment of a strong Solar PV market supply chain. It also supports in promoting/ maintaining a strong network of technical manpower.

All together 75 PQ solar companies are members of SEMAN. A list of these prequalified companies is annexed as Annexure-1.

2.11 LEGAL PROVISIONS ON SOLAR PV

2.11.1 Overview

GON has introduced the Renewable Energy Subsidy Policy and its delivery mechanism in 2000. Since then AEPC has been providing subsidy support for various Renewable Energy Technologies (RETs). With AEPC's recommendation, the subsidy policy has been revised on a regular basis. In 2006, the government of Nepal promulgated the Rural Energy Policy. Presently, AEPC has been implementing GON's new subsidy policy for renewable energy 2069 BS and renewable energy subsidy delivery mechanism 2070 BS.

The subsidy for different renewable energy technologies including solar energy systems is channeled through Central Renewable Energy Fund (CREF). The CREF has been established under the supervision of AEPC to administer the subsidy fund established by GoN and NRREP.

Pre-qualified companies claim subsidy on behalf of users and provide after sale services to the HHs.

2.11.2 GON's Subsidy for Solar PV

Subsidy for SHS/SSHS: AEPC/NRREP has been supporting for promotion of various solar system including solar home system, small solar home system, institutional solar photovoltaic system, and photovoltaic pumping system. According to the current GON's subsidy policy, different subsidy schemes are provided based on size and location. For this purpose, all the Village Development Committees (VDCs) are classified in three different categories: very remote, remote, and accessible. Similarly, the subsidy amount is higher for bigger systems. A summary of the subsidy provisions is presented in table 3 below.

The additional subsidy of Rs. 2500 per household will be provided to household with single woman, backward, disaster victim, poor, and endangered ethnic group as identified by the Government of Nepal.

Subsidy for ISPS, SPS: The maximum subsidy amount of 75 % of the total systems cost but not exceeding Rs. 1, 000,000 will be provided for solar photovoltaic system to be installed in public


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institutions like school, health post. If the system is used only for lighting purpose in religious place, subsidy amount will be same as the SHS. The subsidy for the PV pumping system for drinking water to be managed by community will be provided up to 75 % of the total system cost but not exceeding Rs. 1,500,000 per system.

2.11.3 Subsidy Delivery Process on S/ SHS:

Solar Companies prequalified by AEPC must submit the specified subsidy application form as well as the letter of recommendation of the District Energy Environment Section/Units to AEPC. The subsidy application forms are distributed by AEPC to the companies by giving certain time frame of maximum 120 days, on the basis of the past performance of the companies, sales and distribution of the materials and equipment and stocks. The companies also submit the electronic copy of the subsidy application form and data by using the AEPC prescribed software.

After receiving the applications, AEPC carries out the preliminary assessment and evaluates the condition and documentation for subsidy approval and if it finds appropriate, it will recommend CREF for the payment up to 70 % of the subsidy amount as an advance against the bank guarantee. AEPC recommends CREF for approval of the subsidy within the maximum of 60 days after confirmation for fulfilment of all criteria for approval of subsidy by evaluating the documents.

CREF further examines and evaluates and if it finds that criteria have been fulfilled, it will approve the subsidy and disburse the 90 % subsidy amount with adjustment of the advance payment. The remaining 10 % subsidy amount will be retained as ASS guarantee, which is subsequently released upon the evaluation of the promised ASS after a year.

2.11.4 VAT/Tax Exemption in import of Solar PV components

Since the fiscal year 1998/99, 1 lighting custom duty is charged for imports of Solar PV module, Battery, Charge controller and Solar LED DC lights whereas VAT is exempted for these items on the recommendation letter provided by AEPC.

Similarly, In case of solar pumps, solar inverters and other accessories like cables, junction box, switches, etc., the custom duty and VAT are imposed according to the existing provision. Below table is a summary of Custom Duty and VAT details on Components used in Solar PV Technology

Table 5:Vat /Tax exemption on different solar technologies

Solar Technology	Custom Duty	VAT
SSHS & SHS	1 lighting custom duty on solar components like solar panel, battery, charge controller, solar LED DC lights. But custom duty imposed on other accessories like cables, junction box, switches, etc.	Exempted VAT on solar components like Solar panel, battery, charge controller, solar LED DC lights. But VAT imposed on other accessories like cables, junction box, switches, etc.
ISPS	1 lighting custom duty on solar components like Solar panel, battery, charge controller, solar LED DC lights. But custom duty imposed on other accessories like Solar Inverter, cables, junction box, switches, etc.	Exempted VAT on solar components like Solar panel, battery, charge controller, solar LED DC lights. But VAT imposed on other accessories like Solar Inverter, cables, junction box, switches, etc.
PVPS	1 lighting custom duty on solar components like Solar panel, charge controller. But custom duty imposed on other accessories like Solar Pumps, cables, junction box, switches, etc.	Exempted VAT on solar components like Solar panel, charge controller. But VAT imposed on other accessories like Solar Pumps, cables, junction box, switches, etc.

Table 6: Subsidy provisions for different solar PV systems

Different Solar PV systems	Subsidy Amount in Rs		
	Category "A" VDCS	Category "B" VDCS	Category "C" VDCs
Small Solar Home System[1] with 10 Watt peak(per HH system)	5000	4800	4500
20 Watt peak-50 Watt peak Solar PV system(per HH per system)	7000	6200	6000
>50 Watt peak Solar PV System (per HH per system)	10000	9000	8000

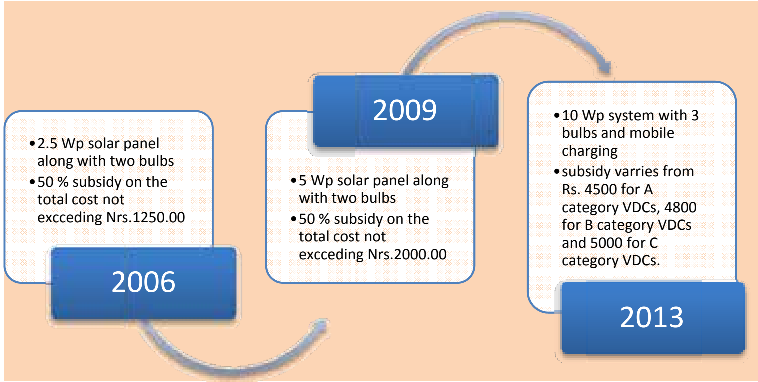

Figure 13 : RE subsidy policy for small scale solar home system (source: RE subsidy policy 2006, 2009 & 2013)

In the initial phase, there was no categorization for subsidy in SSHS: subsidy was USD 20 per SSHS per HH all over Nepal. However, in 2013, the policy included different subsidy rate for three different category of VDCs (A: Very remote, B: Remote and C: Accessible) as demarked by the MoFALD.

2.12 MONITORING & QUALITY ASSURANCE

Various activities are conducted to ensure that the quality product is supplied and installed accordingly in the beneficiaries' households. These activities can be categorized into three categories: Pre Installation, Installation and Post Installation phases.

Pre Installation	Installation	Post Installation
Qualification of companies	Certified Installers	Mandatory ASS
NEPQA compliance test by RETS	Certified Components	Quality monitoring and verification
		Technical monitoring by RETS

Table 7 : Different phases of MQA activities

2.12.1 Quality Control

As per the existing Renewable Energy and Subsidy Policy and Delivery Mechanism, all the solar PV products should meet the NEPQA compliances to be eligible for the subsidy and other exceptions. Basically, all products must pass Product Introduction Test (PIT) and Random Sampling Test. Different testing standards are defined for different size products: 5 Wp and below category, 5 Wp to Less than 10 Wp category,10 Wp and above 10 Wp category.

2.12.2 Test I- Product Introduction Test (PIT)

Product Introduction Test (PIT) is carried out before importing or introducing Solar PV System and its components for the first time into the market. Three samples from each new product are normally required to be tested. As of now, all together 260 solar panels, 86 batteries, 33 charge controller and 75 bulbs have successfully gone through the test.

2.12.3 Test II- Random Sampling Test (RST)

Random Sampling Test is carried out by collecting random samples from the warehouse of the importer / manufacturer. On the importer's / manufacturer's request and based on the approved sampling plan RETS' technician collects random samples from the available lot and conduct testing

as per approved testing procedures. After approval of RST test, products enter the market. In total there are 181 solar panels, 10 batteries, 29 bulbs and 18 charge controllers that have successfully passed the test. A summary of PIT and RST are presented below:

Table 8 : Summary of RETS testing of solar bulbs

RETS testing of Bulbs	PIT	RST
Total numbers of bulbs	75	29
Capacity Range of bulbs	2-6 Watt	2-6 Watt
Number of Manufactures	25	10
Type of bulbs	WLED	WLED
Local companies applied for testing	20	9

Table 9 : Summary of RETS testing of solar modules

RETS testing of Solar Modules	PIT	RST
Number of manufacturers	44	21
Model	260	181
Watt Peak (Wp)	3.2 to 260 Wp	10 to 260 Wp
Up to 10Wp	21	11
Local companies applied for testing	37	25

Table 10: Summary of RETS testing of Solar Battery

RETS testing of Solar Battery	PIT	RST
Number of manufacturers	16	4
Model	86	10
Brand (type)	3	1
Capacity (AH)	10-200 Ah	20-110 Ah
Voltage (V) in range	12V	12V
Local companies applied for testing	15	6

Table 11: Summary of RETS testing of charge controller.

RETS testing of Charge Controller	PST	PIT
Number of manufacturers	22	10
Model	33	18
CC Type (Series and sunt PWM)	2	2
Charing Current Range (A)	3-60A	3-60A
Load Curent Range (A)	3-60A	3-60A
Local companies applied for testing	19	10

Testing of components of solar PV system requires different time period. Solar panels usually take a maximum of 10 days to go through the entire test. Similarly charge controllers take 14 days, bulbs take 45 days and batteries take 60 days. In addition to that, few additional days will be required for analysis and production of reports. Due to the limited infrastructure and human resources, it takes significantly longer to get products tested. It was learnt that such delays seriously impact on the solar business, as sometimes they need to wait more than a year just to get the test results.

2.13 FINANCING MODELS PREVALENT IN RENEWABLE ENERGY SECTOR OF NEPAL

2.13.1 Overview of Banking Sector in Nepal

The Nepalese financial market is composed of banking (BFIs) and non-banking (NBFIs) sectors. Nepal Rastra Bank (NRB), the central bank of Nepal which supervises the bank and financial institutions and guides monetary policy, was established in 1956. Banking sector comprises NRB, commercial banks, and development banks. Until mid-1980s only 5 BFIs and NBFIs have been providing financial services, which were increased to 253 until 2013 (NRB, 2013).

There are all together 32 commercial banks with 1,425 branches, mostly operating in urban areas but also having few branches in rural areas. Similarly, 88 development banks (19 are national level and 69 are district level banks) are currently operational in the country.

Non-banking financial sector comprises of 69 finance companies, 24 Microfinance Development Banks –MFDBs (2 are regional level and 22 district level), 36 Financial Intermediary NGOs (FINGOs), 29,526 cooperatives (Saving and credit – 44 %, Agriculture -24 %, Multipurpose – 13 % and Others – 19 %).

According to the World Bank Report (2006) only 26 % of all Nepali households have a bank account, and 45 % prefer to have savings at home while 53 % prefer to borrow from the informal sectors such as friends and relatives. Even if the number of BFIs and NBFIs increase, most households -

In 2013 NRB's Unified Directives (2013) were endorsed with the crucial step for motivating BFI's further involvement in this sector. The directives clearly state that the loans and advances, up to USD 600/beneficiary household, disbursed to micro-hydro installation with maximum 50 kW capacity, SHS, solar cooker, solar dryer, solar pumps, biogas, improved water mills, improved cook stoves, and for wind energy installation will be counted as deprived sector lending. The BFIs can fulfill their respective deprived sector lending obligation through financing in this sector

Source: Nepal Rastra Bank, 2013

also those who have accounts at banks – are discouraged to borrow from BFIs and NBFIs mostly because they require physical collaterals and offer high interest rates (Ferrari, Jaffrin, & Shrestha, 2006).

Financing on RETs has evolved as one of the major opportunities for BFIs and NBFIs. High upfront costs of RETs and the lower paying capacity of rural households have led to a financial gap in accessing clean technologies, including solar PV. The exact number of BFIs and NBFIs involved in this sector is not recorded. However, based on survey and literature review, table 27 provides an approximate number of BFIs and NBFIs involved in this sector directly or in coordination with AEPC and other promotional Organisations.

Table 12 : BFIs and NBFIs involvement in the sector

Category	Institutions Name
Commercial Banks: Class "A" BFIs licensed by NRB	9 BFIs: Bank of Kathmandu Limited, Himalayan Bank Limited, Kumari Bank Limited, Kist Bank Limited, Nabil Bank Limited, Laxmi Bank Limited, Commerz and Trust Bank Limited, Sanima Bank Limited, Civil Bank Limited.
Development Banks: Class "B" BFIs licensed by NRB	2 BFIs: Clean Energy Development Bank Limited, Ace Development Bank Limited
Micro-credit Development Banks: Class "D" NBFIs licensed by NRB	6 NBFIs: National Cooperative Bank Limited, Sana Kisan Bikas Bank Limited, Nirdhan Utthan Bank Limited, Chhimek Bikas Bank Limited, Deprosc Laghubitta Bikas Bank Limited, Jeevan Bikas Samaj.
Local Financial Institutions (LFIs) excluding class "D" NBFIs: Licensed by Department of Cooperatives	Approximately 380 NBFIs (mostly cooperatives): These NBIs have been involved with BFIs and BCU for wholesale loans to install various RETs. Most of these started financing RETs after the series of technical advisory services from various Winrock implemented projects and AEPC.

Source: Winrock International, 2013 and Field Survey, 2014

2.13.2 Financing in RETs

The banking sector's increasing involvement in renewable energy is good news for Nepal. The financial products that are designed for renewable, such as micro hydro, solar and biogas, are steps towards capital market creation in the area of renewable. A policy to reduce interest rates by the central bank on these products could go a far way to expand the renewable portfolio in Nepal. Even though the upfront investment of the RETs is high, one can save significant amounts from its running cost, as it demands very low operating cost. The initial investment of such technologies in most cases will be repaid within their lifetime.

It was found that Nepalese financial institutions have so far mobilized ~ USD 11 million (which is only 0.12 % of the total loans and advances served by Nepalese financial institution) of loans in RETs. Clean Energy Development Bank Limited's (CEDB) contribution is the highest with 42 % on the total RET lending portfolio.

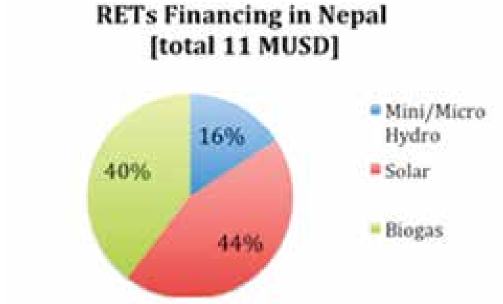

Figure 14 : RETs financing in Nepal

There has been a continuous effort from AEPC and some other I/NGOs in introducing workable credit financing in the renewable energy sector. Nepal Rasta Bank through its policy guidelines encourages commercial and development banks for lending in renewable energy technologies. The RETs are now also considered as the deprived sector. As of now, Only 1 BFI (CEDB) has provided loans in all sectors whereas 6 BFIs are involved in Mini/Micro hydro, 5 in solar and 1 in biogas sectors.

Over the last decade, AEPC introduced a few credit financing mechanisms in major RETs including solar, biogas and micro

hydro. It is believed that such activities have significantly contributed to address some of the barriers to credit delivery.

A summary of these credit financing instruments are presented below:

2.13.3 Micro Hydro Debt Fund (MHDF)

The Micro Hydro Debt fund (MHDF) was established by Energizing Development (EnDev) and GIZ for AEPC, which is earmarked solely for lending to MHPs. In addition it was also an attempt by AEPC/GIZ to let banks be more familiar with MHPS and after few successful endeavors, banks will find the sector as profitable portfolio and a commercially sustainable business venture. The MHDF is currently operational through a competitive bidding among financial institutions. Himalayan bank and Clean Energy Development Bank have been selected as the two partners and the fund has been equally placed at these two banks.

Under this modality, 19 Micro Hydro Projects (10 MHPs from Himalayan Bank Ltd, 9 MHPs from Clean Development Bank Ltd) have been supported. Approximately NPR 40 million credits have been mobilized (CREF, 2013).

Key lessons learnt: Administrative hassles like long documentation and time taken for assessment and collateral issues were identified as the major problems in this modality. In addition need of more outreach for FIs was felt necessary with proper capacity building and technical assistance.

2.13.4 Credit financing Solar Home System

AEPC jointly with Winrock International under its Energy Sector Assistance Program II, implemented a project called: 'Credit Financing SHS'. The overall objective of the project was to find viable model such that SHS can be disseminated via the mixture of subsidy, equity and a loan component. The budget came from ESAP II and the total fund that was used for this project was slightly over NPR. 22 million for a three-year implementation period. It was said that over NPR. 23 million wholesale loans provided by urban partner banks and over NPR. 40 million loans provided by LFI to individual users. Under this approach over

9000 SHS disseminated and it was very interesting to know no any default reported by banks and in many cases all loans have been fully repaid within the tenure. This mechanism also practiced multiple loan provided by banks once the partnership was built between the LFIs and themselves. In addition, insurance provision was also established. In total insurance of 2200 SHS was done.

Loan portfolio and performance:

- Over NPR. 23 million wholesale loan provided by urban partner banks
- Over NPR. 40 million loan provided by LFIs to individual users.
- Over 9, 000 SHS disseminated
- Micro insurance of over 2,000 SHS was done.
- No single case of default was recorded.

Key lessons learnt:

- Physical inspection of LFIs prior to selection is necessary
- There should be no gap of subsidy during the course of implementation
- After sales service is of paramount importance for timely repayment of loan
- Consultation with Solar Electrification Manufacturers Association is necessary

2.13.5 Credit financing of the Biogas Plant

To allow local MFIs to flow credit towards the construction of biogas plants and to provide credit facilities to the users where FIs are not prevalent, the Biogas credit fund was established in the year 2000 under the Alternative Energy Promotion Centre (AEPC) with grant support of 2.5 million Euro from kfw to the GoN. The credit fund would be provided to the MFIs, which would further on lend to the biogas consumers.

Loan Portfolio and Performance:

- Total number of beneficiary MFIs: 442
- Total loan investment: NPR 333 millions
- Total loan repayment: NPR 286 millions
- Total outstanding loan: NRP 47 millions

- Total Biogas installed: 25,000
- Total district coverage: 47 districts

Key Lessons learnt:

- To minimize risk AEPC should have the collateral security for the loan
- Abrupt stoppage of the BCU activities has huge effect to the loan repayment. Therefore, there should be a clear cut policy on continuation or discontinuation of the BCU activities
- Training, capacity building and awareness program should be embedded in the program especially to the MFIs and the potential users
- Source of repayment needs to be determined prior to loan disbursal of loan
- Field visits needs to be conducted before approval/disbursal of loan


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3. PICO PV MARKET ASSESSMENT

3.1 ASSESSMENT OF SOLAR PV MARKET

Solar Lanterns (normally 1-2 Wp) are comparatively new but widely available in the Nepalese market. They are mostly used as a back-up tool to cope with the long power cuts in the grid connected households. Small Solar Home Systems are good for smaller rural families to meet their immediate lighting demand and mobile charging requirement. Likewise, the Solar Home Systems are widely popular products within the Solar PV sector (particularly 20 Wp systems). 40 Wp is also a popular size that can be used for operating wide ranges of basic appliances including TV.

The first Solar PV Company in Nepal was established in 1991/92 initiating the promotion of solar powered technologies in Nepal. The use of solar PV power for rural electrification gained momentum only after the successful launching of Pulimarang Village Electrification Project in late 1993. The success of the Pulimarang project played a pivotal role in attracting the government's attention towards the PV technology as a means to rural electrification.

Private sector involvement is very much prominent in the solar sector and was started in early 90's. As of today, Nepal's solar private sector is consisting of 108 Solar PV companies, out of which 75 are AEPC pre-qualified companies for disseminating SSHS & SHSs throughout Nepal. The pre-qualification enables the companies to participate in the GoN's subsidy activity in the Solar PV sector. The majority of these companies are located in Kathmandu and have distributers in different areas with well-established outreach. They either function through distributers located at development region, district headquarter or district hubs or through the agents.

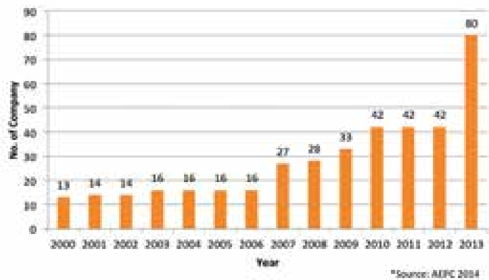


Figure 15: Solar PQ companies

Solar Electric Manufacturer's Association Nepal (SEMAN), the umbrella Organisation of Solar PV companies working in Nepal, was established in 2000 A.D.

3.1.1 Companies wise SSHS & SHS Installation Status

The number of installation per company varies greatly: from only 60 to 12,912 systems. There is only one company that installed more than 10,000 SSHS. In an average up to the year 2013/14 one company has installed 1,645 SSHS systems

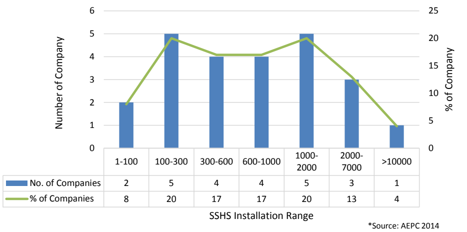


Figure 16 : SSHS installation by companies

The figure below presents cumulative SHS installation numbers per company throughout the country as per January, 2014.

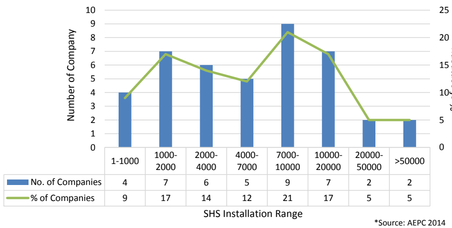


Figure 17: Number of SHS installation by companies

On average, one company installs 9,772 SHS with a high variation in numbers, ranging from 339 to 60,493. Some companies have recently joined the sector and few others have been engaged from the very beginning. There are only two companies who have installed more than 50,000 SHS.

The supply chain for Small solar Home system (SSHS-Solar PicoPV) and SHS is the same. The following diagram and table summarizes the SSHS and SHS supply chain adopted throughout Nepal.

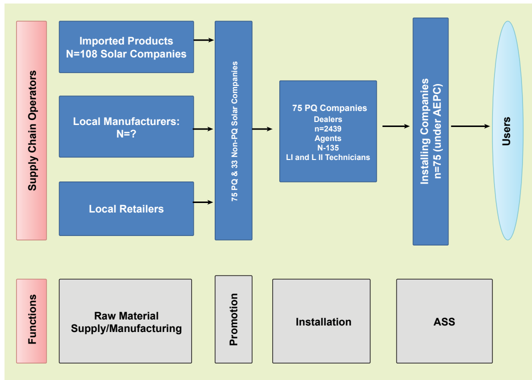


Figure 18 : Supply chain of SSHS/SHS

Table 13: Supply Chain Description and Assessment

Chain Functions	Actors	Responsibility/Process
Import/ supply of components and accessories	10 Solar PV companies	Importing solar panels, batteries, inverters and charge controllers; mostly from South and East Asia
		Supplying panel mounting structure, lamps, cables, junction box, switches, etc.
	Local Retailers	
Manufacturing/ fabrication of components/ accessories	Very negligible numbers of manufacturing companies	Manufacture of switches, junction boxes, cables, etc.
		Two companies locally manufacture batteries
Assembling of Solar PV system	Importer and wholesalers (upto 20 companies)	Assembling of solar components and accessories
Promotion	75 pre-qualified companies and local retailers/distributors	Create demand among the users and are responsible for arranging all documents for subsidy, training user about the operation and maintenance of the solar systems
Installation of SSHS/SHS	PQ companies and local retailers/distributors and agents	Only 75 prequalified solar companies are eligible to install SSHS and SHS under the government subsidy procedure.
		All Solar PV companies have their own distributors and dealers for the installation of SSHS and SHS.
		Presently there are 2,439 dealers and 135 agents all over the country
		The installation is done by LI and LII technicians
After Sales Services:	75 PQ companies and their dealers/ distributors	Two times ASS in the 1st year of installation is mandatory for the company after the date of installation

3.2 MARKET MAP OF SOLAR PRODUCTS AND SUPPLY POTENTIAL

A total of 108 private companies across the supply chain are actively engaged in providing supply of solar PV in Nepal. Similarly, there are 640 branch offices of the companies involved in SHS and SSHS promotion. The Central Development Region has the highest number of branch offices with 153 (24 %) branches and the lowest number (92) of branch offices is located in the far western development region. Similar is the case for agents of those branch offices, the Central development region has the highest number of agents, i.e. 37 (27 %). But the number of dealers is higher in Mid-western development region which is 738 (30 %) of the total dealers in the country. However the highest number of dealers (205) is located in Kathmandu (Winrock, 2014).

The solar energy system major components: solar panel, charge controller and battery are imported mostly from South and East Asia and assembled in Nepal. Out of total 75 pre-qualified companies, only about 10 major companies are engaged in imports of the solar components. Only few products are locally manufactured. From the interaction, it was learnt that in most cases importing of such products is cheaper. There are limited manufacturing companies involved in this sector.

The two companies: Kulayan Energy Pvt. Ltd. and Kulayan Battery Industries Pvt. Ltd. have been supplying locally manufactured 'Sunera' brand battery to the Nepalese solar market; however it constitute less than 5 % of the whole batteries business. Two solar tubular batteries are also promoted by the Kulayan/Sunera, Jagdamba; however again the demand is not so big.

The solar PV market is highly dependent on the subsidies. Only those products which are subsided have been promoted in the market. In general, prices are controlled by importers or national level distributers located at Kathmandu. However quality of products is regulated by national level as solar products need to pass through RETs quality test compliance.

Based on the interaction and discussion with 33 local retailers /distributors and agents

from the far and mid-western development region, no fixed product flow channel exists, as the products reach to the users thought different ways:

(1) Solar products either reach the user through the agents.

(2) People come to the retailers/wholesalers and buy the products of their choice.

Schematic representation of the existing supply channel is shown below:

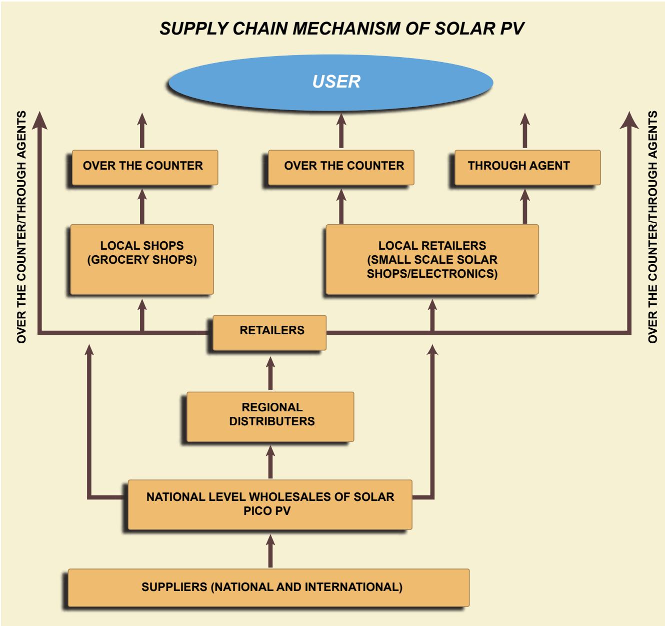


Figure 19: Supply Chain Mechanism of Solar PV

3.3 PRICING DETAILS OF SOLAR PICO PV

The price data tend to vary and depend on various factors like transport influence on the price of pico PV/SHS. In addition, prevalence of different brands of products with difference in quality has made cost more variable. The selling prices of SHS with subsidy are on the higher side and that has been from the very beginning of the subsidy programme, as the programme(s) has let the price be determined by the market and required after sale services.

From the survey data, it was observed that the average price that end users paid for SHS and SSHS are NRs. 18,875 and NRs. 7,060 respectively.

The system price is influenced by various external conditions including the location and system size. The following trend represents, where possible, the final per Wp costs for the consumer.

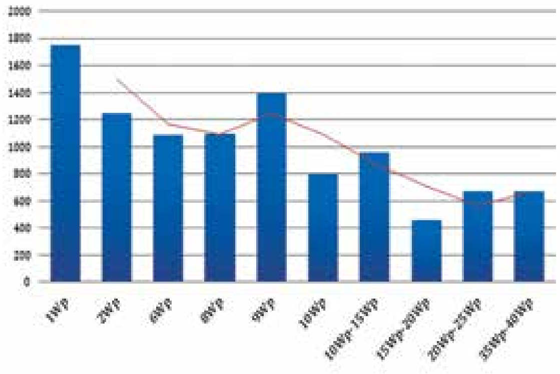


Figure 20: Trend line of price per Wp of Solar System

The price of per Wp is found to be decreasing as it moves from lower to higher capacity. The cost of the 10 Wp or similar systems is between NRs. 6000-8500.

3.3.1 System pricing on solar PV system

In most cases, the system price is determined by the wholesalers/importers (PQ companies who buy the products from international market through LC). The wholesalers, after adding their profit value, sell their products to the dealers/retailers.

Depending upon the transportation and other overhead costs, the dealers/retailers add certain costs and sell to the users. During the field visit, lots of inconsistencies were observed in terms of retailer price for the same products. It is believed that the long supply chain and various profit margins are the major causes of such inconsistencies.

Based on discussions/interactions with various wholesalers/retailers/distributors, a typical 20 Wp system costs around 5 to 6 thousands at wholesale level (subsidy will be additional). At the user level, the same product is sold up to Rs. 9500 (considering that the subsidy total price will be around Rs.17,000). The retailers after incorporating all overheads and transport costs, fix the end user price. Interestingly, the same product can be bought at around Rs. 11,000 if it is without subsidy. In case of 10 Wp SSHS, one can buy the product from the retailer at the rate of Rs. 6,000, but the same system is charged Rs. 4,500 under the subsidy scheme. That clearly shows that beneficiaries are getting a direct financial benefit of only Rs. 1,500 (about 25 % of the total subsidy).

Tentative Value Chain (price) in 10 Wp System (Ever Exceed)

Tentative Value Chain (price) in 20 Wp System

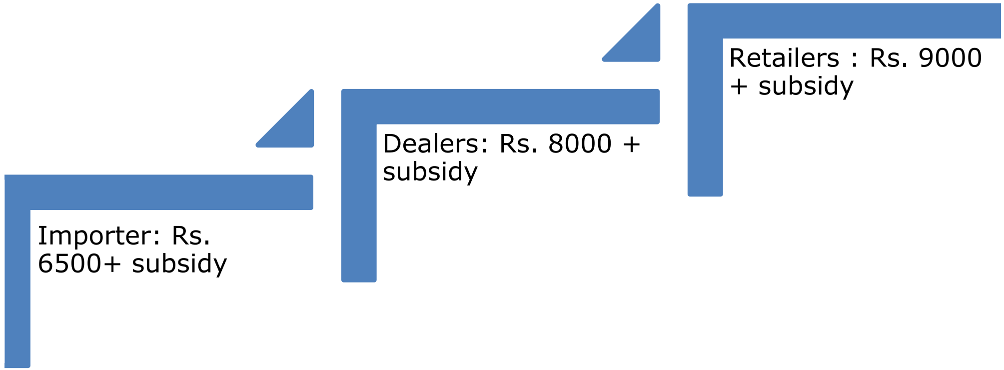


Figure 21: Tentative Value Chain

Where Subsidy Really Goes?

Globally, incentives in the RE sector are following two basic concepts: (i) sector support approach; (ii) upfront investment support to beneficiaries. In some countries, huge amounts of money are deployed to strengthen the market, assuming that the competitive market will ensure more reliable services, incorporating credit financing. Others believe that the subsidy should go directly to the end users (beneficiaries) to increase their access to the renewable energy technologies.

In the case of Nepal, the subsidy support should go directly to the user, however, the majority of the support amount is spent with the intention to provide quality and good service delivery of the product.

The following diagram explains indirect costs associated with the service delivery. Normally, companies do not count on getting back the 10 % of the subsidy allocated as retention amount. Furthermore, the RETS and SEMAN have special fees that companies should pay. During installation, the local retailers charge additional 2-4 thousands per system to cover their expenses. There is also indirect cost associated to mitigate the losses during document handling.

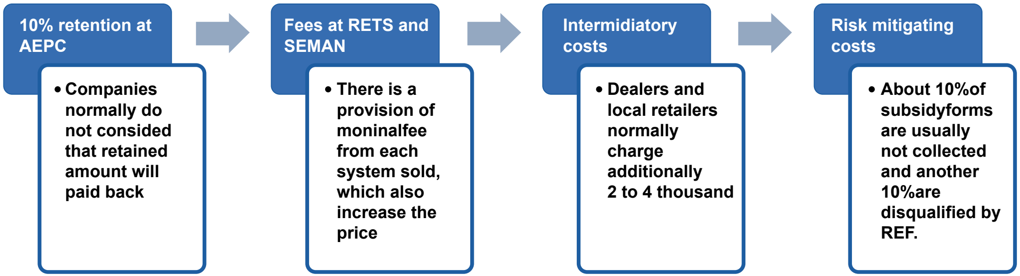


Figure 22: Indirect costs associated with the service delivery

3.4 HH ENERGY USE PATTERNS

A household level survey was conducted to establish a pico PV baseline. All together 101 sample households were selected for this purpose. Out of the total HHs surveyed, 37 were with solar PV (pico PV and SHS).

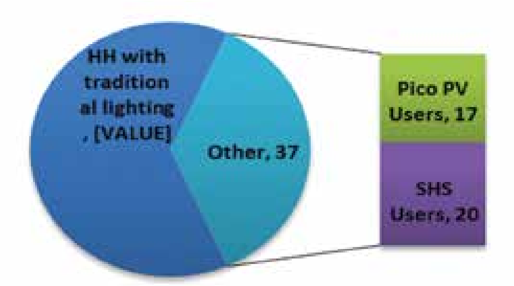


Figure 23: Type of Sampled Household

The daily energy demand of any household was estimated on the basis of type and number of appliances, their capacity and number of hours in use.

Traditional energy sources are still prevalent in the rural households. Most of the HHs use firewood to meet their cooking energy demand. A significant number of families use dry cell batteries for lighting and operating appliances like radios. Kerosene is found to be major source of lighting. Solar energy also takes up a significant portion as lightning source of energy.

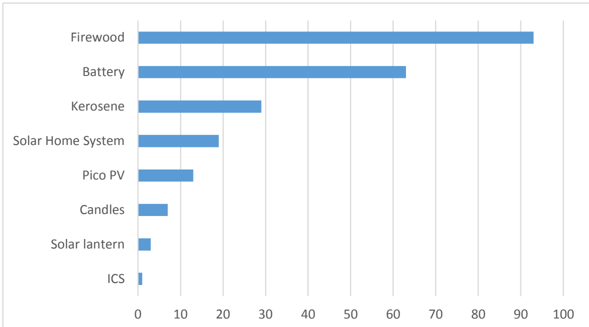


Figure 24: Uses of different sources of Energy

3.4.1 Lighting Sources

In terms of lighting, households that are not electrified exclusively use "Jhaaro" (40 %). In addition, there is a sufficient contingent specifying that they continue to rely on batteries (19 %), kerosene (12 %), and candles (8 %).

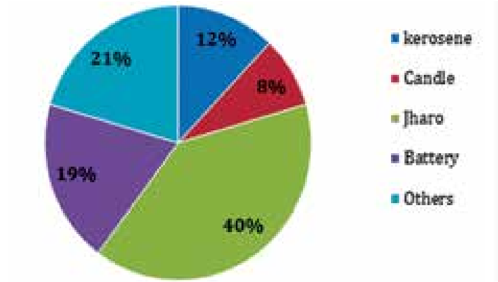


Figure 25: Non Electrified HH Lighting Sources

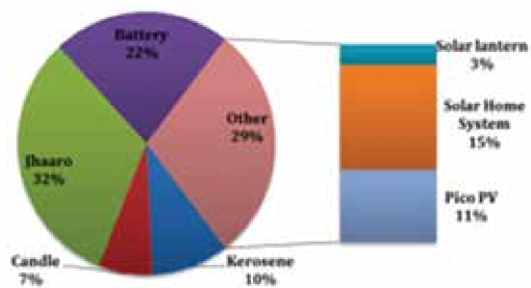


Figure 26: Lighting Sources in sample HHs

As one would intuitively expect, there is discernible variation in the energy sources used for lighting, based on levels of material deprivation. Households characterized by low living standards are among non-electrified households who still rely on cheaper energy options like "Jharro".

"Jharro"

"Jharro" is a source energy which uses resin that is locally extracted from the tree called Kote salla (Pinus roxburghii). It is gathered by inducing a deep "wound" on the pine tree, forcing it to produce locally a high amount of resin in order to "cure" the wound. This high resin content wood layer is cut away after a week and burned in small sticks to generate light. Burning "jharro" sticks are typically placed on an elevated stone or mud pile or on a hanging metal plate at a height 40–50 cm from the floor.

This average luminance from the burning "Jharro" sticks is less than 1 lx Lukos, 20071. These low lighting levels make it just possible to move around the room and to do some general work close to the light source, but the lighting is not adequate for any visually oriented tasks such as reading.

"Jharro" has been identified as one of the major causes of indoor air pollution and has a direct chronic impact on people's health, such as respiratory chest diseases, asthma, blindness and heart disease1.

3.4.2 Solar Panel Size and Bulbs Type

Under the pico PV category (below 10 Wp), the average system size was found to be 6 Wp. In this category, the average number of bulbs was 2 and the majority of them were White LED. Similarly, above 10 Wp system, the average size was found to be about 20 Wp. It was observed in the field that 20 Wp is very popular in the surveyed districts as it exactly meets the current lighting needs of rural people. The average number of bulbs used per SHS was 4. Both the White LED and CFL bulbs are used with most SHS.

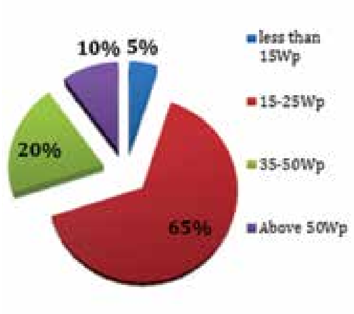


Figure 27: Capacity wise distribution of Pico PV

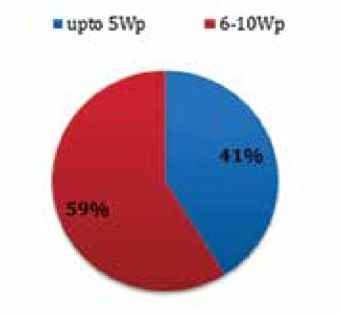


Figure 28: Capacity wise distribution of SHS

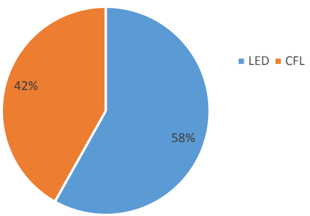


Figure 29 Type of Bulb

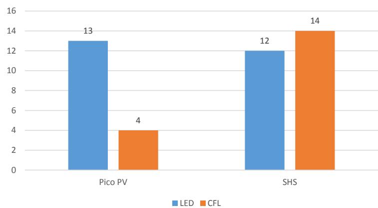
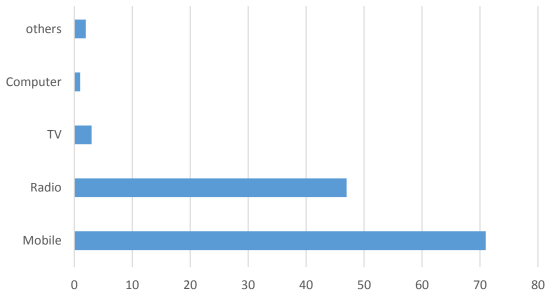


Figure 30: Type of bulb according to different size of Solar

3.4.3 Electric Appliances at HH level

Out of 101 households surveyed, 71 household own mobile, 47 own radio and 3 have a TV. There was one household having a computer. Other electric appliances include torch lights. This concludes besides lighting, the primary function of electricity includes mobile charging and operating radio.

Figure 31: Major use of Solar Light in HH



Around 40 % of mobile users do not have electricity, but they manage to charge their devices from their neighbors' battery connections.

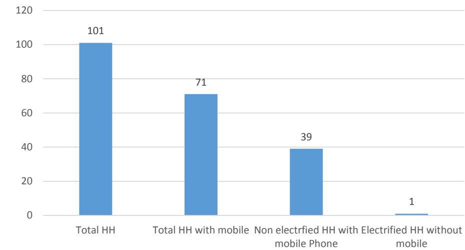


Figure 32: Use of mobile phone in HH

3.4.4 Place of Lighting Use

The survey revealed that the majority of the people use solar lights in the kitchen and the study room, pidi/balcony and toilet. Other places like living room were also found to be important places for lighting. This implies that the majority of HH want a minimum of three lights to use in different places.

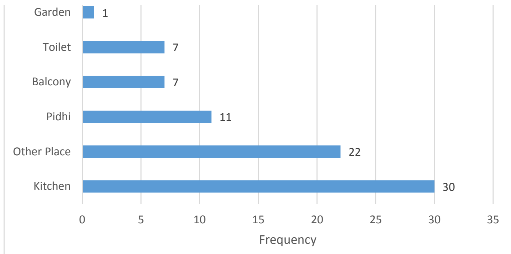


Figure 33: Place of light use

3.4.5 Performance of Solar PV

Performance of solar PV was measured to determine daily usage of solar and its functional capability. **The average use of solar in rural household was found to be 3.8 hours per day.** Light provided by solar PV is found to be well sufficient in the household. Another dimension of solar PV is to find the performance of batteries and other appliances. Respondents were encouraged to rate the performance of their battery and other appliances on a five value scale: very good, good, intermediate, bad and very bad.

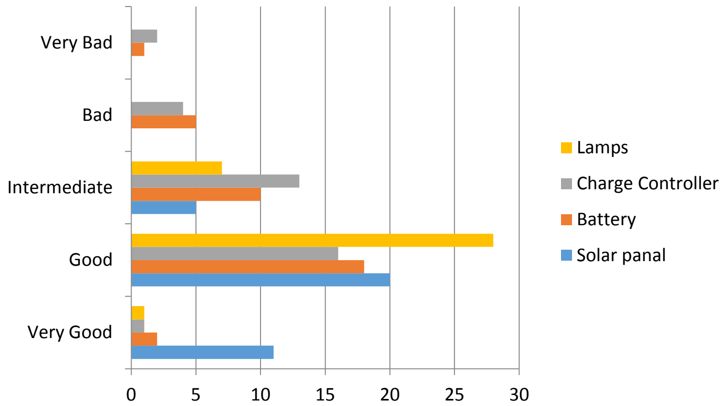


Figure 34: Performance of Battery and Other appliances

The majority of respondents rate all four components of solar as good. The performance of solar panel performance was rated as very good but nominal proportion rated the battery and charge controller as bad and very bad. Regarding performance of charge controller it was observed during the field visit respondents were having severe problems compared to other components of solar, as they tend to malfunction once in a while.

3.4.6 Operation/Maintenance

The users were not made aware of the general maintenance of the systems. Breakage of components during the warranty period (within 2 years) are replaced or maintained by companies but repair of the system was found to be rare. Once the warranty period is over, users normally discard the system if it breaks down or if there is non-availability of technical persons in the village. No habit of spare change was found because of two reasons. First they do not have any knowledge and no proper channel for obtaining spares and maintenance. Secondly, the users have to reach hubs like Dadeldhura, Doti bazar or district headquarters to get access to spares, which brings an extra economic burden to them. But the users are ready to pay the maintenance cost if the technicians come to their house for service.

3.4.7 After Sales Services

An after sales services facility was not found in the study area. Most respondents felt that technicians from the installation companies were unavailable to assist them with repair and maintenance and even when available, their help did not arrive on time. If a component malfunctions within the warranty period then users can seek for the installer company help. Users are provided with a warranty card with which they can ask for after sales service. But users have to take the system to the company by themselves. During the warranty period too, normally the not-functioning parts are replaced rather that repaired. During the field visit it was observed that some systems were not found repaired, but new systems were replaced. These type of issues in the after sales service system are a main reason why most technologies have failed to live up to the expectations in rural Nepal.

3.4.8 Cost of Repairs

Repair works of solar home systems were not significant in the surveyed district. Generally, it is assumed, for warranty period all the repair works are done by the installer company itself and after the initial two years, users have to manage by themselves. Unfortunately, if systems fail after the warranty period, discarding them has become the norm. Therefore, no major costs were associated with repairing components.

Major problems were not reported in solar panels and switches. The battery is the most repaired part of a solar home system. The average cost for repairing a battery was found to differ in each household, ranging from a hundred to a thousand NPR. Therefore, the average cost of maintaining (replacing) a battery was found to be NRs 600 and NRs. 3500 respectively. Bulbs also present frequent problems but the replacing cost was found to be nominal.

3.5 USERS PREFERENCE IN SELECTING PRODUCTS

Rural households preferred the solar PicoPV system consisting of three lights with mobile charger and a radio. Based on the interactions, carried out with the HHs, it is found that there are clear indications regarding the preferences of the users. Those preferences are given below:

- the system should give a bright light and be affordable;
- multipurpose (lighting two rooms, charging a phone);
- portable and easy to use;
- safe and secure and;
- have a long battery life.

"3 Bulbs with mobile charger Solar"

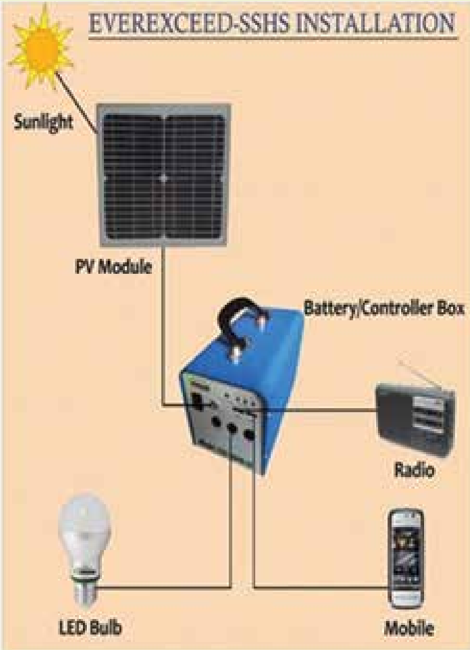


Photo Source: www. everexceedsolarcrop.com

"3 bulbs with mobile charger" is what people ask when they come to buy solar products. This Small home Solar System package (10 Wp) with three lights and mobile charger facility is one of the most popular product in the study area. It has become more affordable for villagers as it provides energy saving technology with portable design. The product is manufactured by Ever exceed Solar Crop and is a Renewable Nepal Test Station (RETs) certified Product.

In Nepal, importing of this product is done by LS solar Company. Nevertheless, other Companies have also been found to be involved in marketing it.

3.6 WILLINGNESS TO PAY

Willingness to pay (WTP) refers to the maximum amount a person is willing to pay in order to receive a good or to avoid something undesired. Various methods have been developed to measure consumer willingness to pay. Considering the given time and resources, a stated performance approach was applied to measure hypothetical WTP of rural households for different solar products. For this section people where asked how much they are willing to pay in bulk purchase and every month to rent to buy a solar product. Rent to buy is a way of paying for products by paying a certain amount every month until the total amount plus interest is met. These figures give the distribution of the willingness to pay for rent to buy schemes. The result listed in figures can be used for creating good financing schemes for future customers in rural areas. To simplify the survey, the following three different solar products with their descriptions and price options were used.

Table 14: Description of Products used in WTP Product Card

Product Card 1 Small solar system only for lighting	Product Card 2 Small solar system with mobile charging facility	Product Card 3 Normal solar home system
Number of lights :1 Hours of light :8 Charge phone: Not possible Radio/TV: Not possible Lamp can be used for working, Studying, cooking, walking and socializing Portable 360 degrees illumination	Small solar home system (up to 10 W) Number of lights: multiple (2 or above) Hours of lights: 12 Charge phone: multiple Radio: Yes, TV: No Lamp can be used for: working Studying, cooking, walking and socializing Portable Illuminated more than one room	40 watt solar home system Multiple lights Hours of light: continues Radio /TV: Yes Small fan: Yes System can be used for: working system, cooking Lamp can be used for working Studying, cooking, walking and socializing Electricity system Illuminates entire house Possible to expand the system with more panels

3.6.1 Determination of WTP

The average WTP amount for solar energy products can be strongly influenced by high and low WTP values. In addition different variables were calculated to know how data is distributed around the mean. Therefore, to better understand the distribution of WTP among households, distribution of WTP was analyzed.

Average WTP for product i.e. solar lantern in purchase is 116 NRs. The purchase range of solar lantern was 0 to 2500 NRs in which two third of the HH was willing to pay in the range of 0 to 2000 NRS for solar lantern. There were also people who wanted to pay more than 2000 NRs to purchase the solar lanterns. For renting Solar lantern one third of households do not want to pay for this product but still half of the 56 % of the household is willing to pay an amount between NRs 25 to 100. Average WTP for product i.e. solar lantern in rent is NRs 82 per month.

Average WTP for Pico PV is NRs 2835 for purchase and NRs. 187 rent to buy. The value for purchasing pico PV ranges from NRs 0 to 5000 in which 62 % of household is willing to purchase Pico PV between 1000 NRs to 5000 NRs. There was a small fraction of people who could only afford below 1000 NRs for purchasing Pico PV. For renting Pico PV more than sixty % of households are willing to pay an amount below 100 to 200 NRs every month to rent to buy Pico PV. The average WTP for rent to buy a Pico PV is NRs 187 per month.

Average WTP for product 3 is NRs. 7439 in purchase and 382 for rent to buy. 20 % of people are willing to pay between 5000-2000 and 31 % of household are willing to pay below 5000. There is also small fraction of people of about 6 %, who are willing to pay more than 20000. The values obtained are not normally distributed but skewed at the lower values and the average is influenced by a view of high stated values. This variation indicates households found it difficult to value this product. For renting solar 58 % of household are willing to pay for an amount from 100 to 500 above to rent to buy a SHS. The average WTP for rent to buy a SHS is NRs 382.

Meaning of different variable are: N are the number of household where the WTP is recorded, Minimum is the lowest value given by households surveyed, and Maximum is the maximum amount given by one of household. Minimum and maximum is displayed to give a better understanding on the range of WTP that exists. Mean is the average WTP and standard deviation shows how much data varies from the mean. Low standard deviation generally means data are very close to the mean, whereas high standard deviation indicates that the data are spread out over large ranges of values.

Table 15: WTP product 1

Solar Products	WTP	N	Min	Max	Mean	Std. Deviation
Solar lantern	WTP to purchase	75	300	4000	**1159**	834
	WTP to rent	72	15	1000	**82**	121
Pico PV	WTP to purchase	78	350	14000	**2835**	2667
	WTP to rent	79	25	2100	**187**	380
Solar Home System	WTP to purchase	57	500	25000	**7439**	6719
	WTP to rent	57	50	5000	**382**	876

(SNV & SETM, 2014)

3.6.2 Factors Determining Willingness to pay

Further intensive analysis was done to know more about factors that determine the WTP of a particular household. The main objective is to demonstrate the relationship between the WTP for the solar products in the product card and the households' income.

The baseline study suggested that there exists no relation between income and WTP for purchasing and renting solar lanterns.

There exists a medium relationship between estimated income and WTP with Pearson's coefficient for purchasing Pico PV.

There exists medium relationship between income and WTP with Pearson's coefficient for purchasing SHS.

There exists medium relationship between income and WTP with Pearson's coefficient for renting Pico PV and SHS.

Therefore higher income level HH is found to be willing to pay for both purchasing and renting SHS and Pico PV.

3.6.3 Household Income

During the survey, each surveyed household was asked to estimate their monthly income considering all income sources. To verify the estimated income, they were asked to specify their entire different income source per season, month or year. Based on these figures, total average monthly income was calculated.

Table 16: HH Annual Income of Survey Districts

	Calculated (NRs)	Estimated (NRs)
Far western mean	77756	83570
Mid-Western mean	96185	97722

Table 13 shows the income distribution over the nine districts: seven in the far west and two in the mid-western region of Nepal. Total calculated income and estimated income of far-western Nepal was found to be NRs. 77756 and NRs. 83570 and for mid-western region is NRs. 96185 and NRs. 97722 respectively which is similar to the national census data of household income 2012. Total income is slightly lower than that of national data which is explained by the fact that the selected sample is at certain distance from the main road. More remoteness of household is expected to have lower income.

Table 17: Nominal Household Income and Per capita Income (CBS, 2012)

	Household Income		**Per Capita Income**		
	Mean	Median	Mean	Median	**Average HH Size**
Far Western	144030	87512	28584	17221	5.1
Mid-Western	159868	104544	30941	19374	5.2
Nepal	202374	127281	41659	25093	4.9

There was a clear pattern of income distribution perceptible in the research area. The market hub centers like Dadeldhura and Doti of far western and Surkhet of mid-western Nepal have a higher level of income than other areas. In addition, high income levels of Darchula and Baitidi can be justified by the fact that their economic activities are basically based on remittance (working in India).

3.7 HOUSEHOLD EXPENDITURE

Energy expenditure generally refers to the sum of money spent on lighting, cooking and other energy needs of HHs. The energy expenditures were found to be approximately 3 % of the HH total expenditure.

The other expenditures are: 62 % on food, 16 % on clothing and 8 % on health related expenditures.

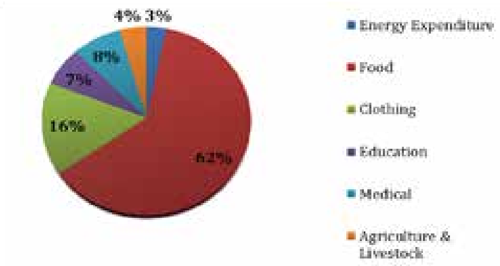


Figure 35: HH Expenditures

3.7.1 Household Expenditure for lighting and Ability to Pay

Household with low income typically use "Jharro" which are collected from nearby forests. In contrast, households with a medium or high income rely mostly on electricity. Table 14 below shows the expenditure on different energy sources which are used for lighting.

Table 18: Expenditure of different energy sources

	Quantity Per month	Expenditure Per month (Rs)
Kerosene	1.8 liter	165
Candles	10	101
Battery	6	130

HHs spend NRs 165 per month for purchasing kerosene and similarly, spend NRs 101 for candles and NRs 130 for batteries.

Hence, the average household expenditure is NRs 1380 per annum for meeting the needs of lighting. The average cost of installation of Pico PV is NRs 6500. This implies the average payback period is around 5 years.

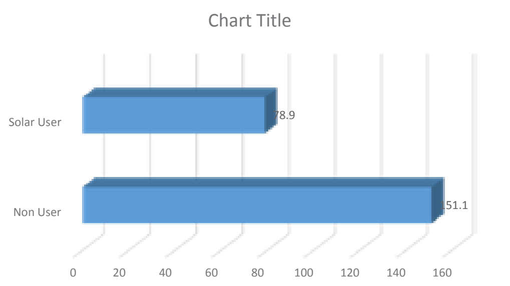


Figure 36: Household Expenditure for lighting solar users vs non user

3.8 AWARENESS AND KNOWLEDGE ON SOLAR AND ITS BENEFITS

The survey addressed various issues concerning emerging renewable technologies, including familiarity of Solar System to the rural household, its benefits, its motivations and intention. Overall, 81 % of respondents knew about the solar energy as illustrated in the figure below.

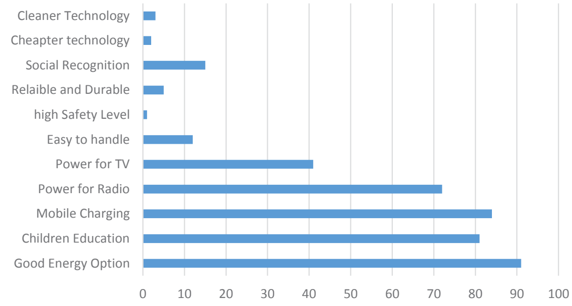


Figure 37: Familiarities of Benefits of Solar

While gauging their understanding on benefits of solar energy, the distribution was similar. Respondents were well familiar with facilities it provides. It is noteworthy that rural people did not mark solar as a cleaner and cheaper technology. In addition they also find this technology as less complex, reliable and durable.

3.9 ATTITUDE SURVEY

In order to determine the attitude of users and non-users of solar, an attitudinal survey was conducted. Below are the results of the attitudinal survey with respect to the 'solar users'.

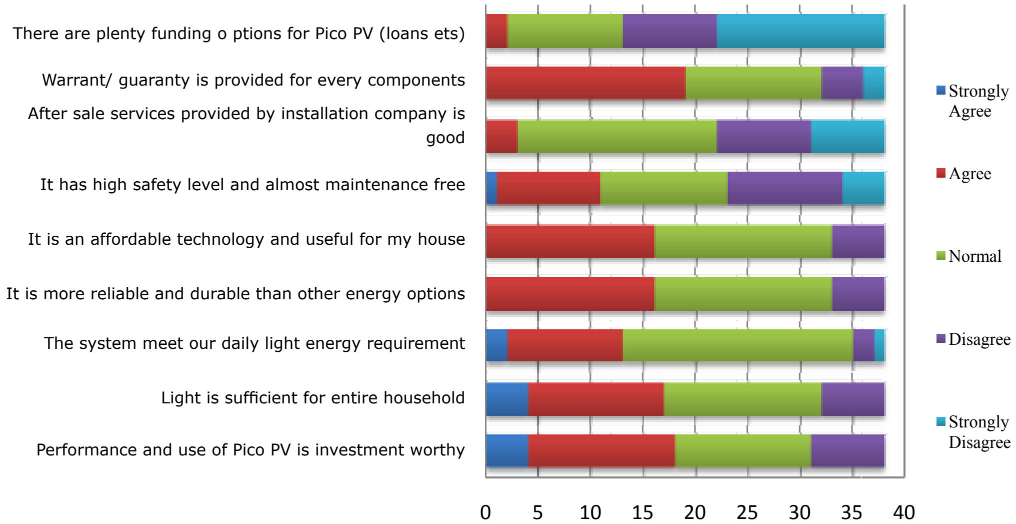


Figure 38: attitude Survey of Solar Users

In addition, this survey was also carried out for the non-users of solar. Below are the results of the attitudinal survey with respect to the 'non-solar users'.

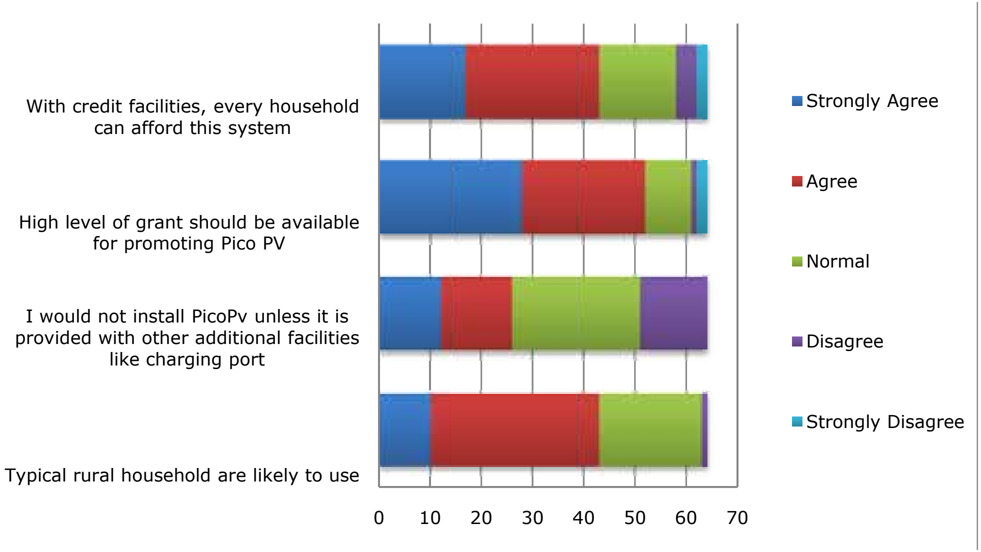


Figure 39: attitude Survey of Solar PV non users

The key findings of this attitudinal survey are:

- Current solar users do not believe that solar PicoPV meets the daily lighting energy demand of the HHs, rather this is a pre-electrification solution, prior to having access to gird electricity.
- Non-solar users are positive in pursuing credit facilities from banks and other financial institutions to purchase solar PicoPV.

3.10 INVESTMENT ON SOLAR PICO PV

3.10.1 Source of Investment (Subsidy/ non-subsidy)

During the survey, nearly 83 % of the households said they did not receive government subsidy for the installation of solar home systems or Pico PV. There could be many reasons for this surprising result. First of all being that agents from the installation company may not have explained the subsidy scheme properly to the users.

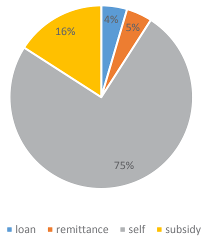


Figure 40: source of financing initial cost of Solar

It is noteworthy to see there was around NRs.1500 cost variation (from the users end) between subsidized and non-subsidized solar products. Normally the retailers charge around NRs. 1500 less for the subsidized products where they claim Rs. 6000-7000 subsidies from AEPC. This observation also exhibits the fact that the real cost of the products is normally paid by the users and most of the subsidy portion goes to the company. In reality, the subsidized products are found to be more expensive than non-subsidized ones.

3.10.2 User preferences on mode of Payment

Households are willing to pay mainly through partial upfront and human labor for installation. The percentages of people, who are willing to pay full upfront payment, are only 9 %. Approximately 25 % of interviewed people responded that they are interested to pay the whole installation cost in installments (monthly).

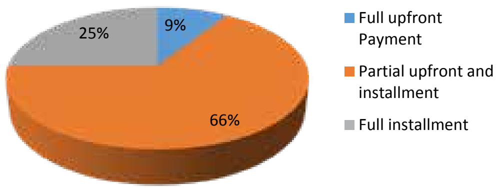


Figure 41: Preferred Payment mode for Solar PV

3.11 INNOVATIVE FINANCING MECHANISMS FOR SOLAR PICO PV

3.11.1 Current Status

The study proposes a procedural framework for integrating FIs/MFIs into the RE sector. The procedural framework builds on the existing Energy/Microfinance Framework and attempts to use the inherent features of FI lending. During the interaction with the sampled households already using solar PV, it was found that most families have taken a loan from their relatives or local merchants with a high interest rate. Most of them realized that they would go for credit financing if such facilities were there. Altogether there are 45 commercial bank, 13 development banks and 15.2 cooperatives (CBS, 2012) in the study area. Co-operatives include saving and credit, multipurpose, agriculture dairy, consumer, communication to others. The major problems regarding co-operatives are that most of them are registered, yet do not exist at the ground level.

Various challenges and issues were identified during the discussions/interaction with 20 sampled financial institutions (13 BFIs and 7 NBFIs), APEC/NRREP, and RET suppliers regarding small scale rural energy financing. The summary of the findings is presented below:

- remoteness creating difficulties in monitoring and supervising loans
- high operation/transaction cost due to remote clients;
- limited decision making in solar financing due to unavailability of technical staff at their institution;
- no product insurance;
- firm Eligible Criteria decreasing number of rural clients/LFIs;
- small size of Loan.

3.11.2 Possible interventions

Henceforth, long-term debt financing is seen as a possible area for solar PicoPV financing. Furthermore, a development program like ESAP, contributing to the strength of rural companies and cooperatives, providing appropriate advisory and business development support along with the technical support. Synchronization of different innovative financing mechanisms in the sector with existing policy and implementing agencies at the macro-level, supply companies, dealers and financing institutions at the middle level and local community and household economy at the micro- level is what is utmost needed.

The prevailing view among stakeholders is that long-term sustainability of Solar PicoPV requires developing robust market implementation mechanisms that will favor sound investment projects, which in turn will attract capital. This will allow finance providers to adopt suitable underwriting practices and expand the available financing to individual projects. Commercial banks have indicated their preference for financing Solar PicoPV project development driven by a sound financing model. Indeed, a result based competitive market would be more supportive for sustainable development of the Solar PicoPV sector.

3.11.3 Prevailing financing models

In general, there are four financing modalities being practiced in the small scale rural energy sector: (i) Government's BFI Modality, (ii) Wholesale Lending Modality, (iii) Vender Financing Modality and (iv) Revolving Fund Modality. All modalities have benefits and weakness, a summary of which is presented below:

Table 19: Benefits and weakness of various financing modalities

Financing Modality	Benefits	Weakness
Government's RET Financing	Interest rates are comparatively low Monitoring is easy, as branch offices can directly monitor and control loan Borrowers need not to contact head office. They can access loans within just few hours of walking Establishes direct network between rural client to urban banks	High operation costs to banks because branches need to work with individual rural client Normally branches require collateral as they do not trust the rural client
Wholesale Lending	Bank's relationship only with legal rural LFIs rather than individual client No individual collateral requirement from the rural client Large potential loan size Opens opportunity for lending in other sector in partnership with LFIs Fulfils bank's deprived sector lending obligation	High interest rate on loan to the ultimate user (due to multiple layers of transitions) Finding of transparent and eligible LFIs is a challenge repayment risk is high as LFIs can take loan from multiple banks
Vendor Financing	Reduces loan monitoring costs because most borrowers (RET companies) are in proximity to BFI office Loan is protected through collaterals Large potential loan size	Most borrowers (RET companies) do not practice well managed book keeping BFI's loan does not count as Deprived Sector Lending
Revolving Fund	Loan available at low interest rate Management committee manages the source and uses of funds catering the genuine needs of rural population	Most funds are grants from donors' and are used based on their priorities High risk of misuse.

3.11.4 Suggested financing model for Solar pico PV

Based on the situation analysis of the existing market, the wholesale lending modality is recommended as the most appropriate financial model for the dissemination of solar PV, including pico PV. Under this model, BFIs do not provide RET loans directly to the target beneficiaries. Rather BFIs and NBFIs go into a loan agreement in which BFIs provide wholesale loan to NBFIs and rural NBFI eventually provide retail loans to their members (target beneficiaries). To make all parties accountable, a tri-party agreement is signed between BFIs, NBFIs and RET suppliers. Figure 33 shows the working principle of this model.

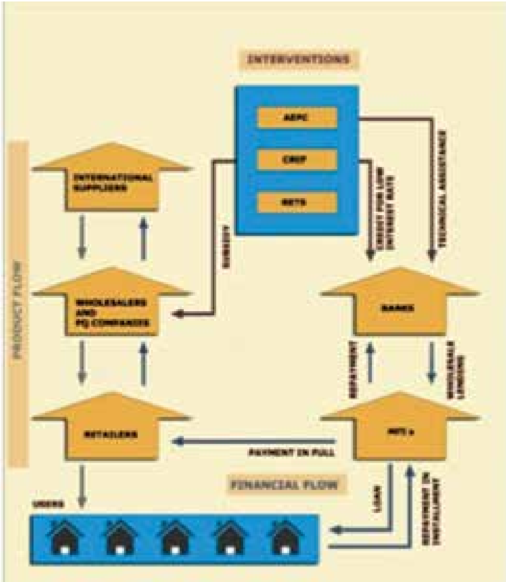


Figure 42: Wholesale Loan Model

There are other means of financing, which are successful in the solar PicoPV sector in the world (mainly in Lighting Africa initiatives). These financing models could be- result based financing, end-user financing, MFI-based micro-lending, engaging the semi-formal and informal financing sector, mobile-payment enabled PLS lending and pay-as-you-go, Payroll Financing etc. However, these financial tools have not been discussed in this publication, considering the availability of sufficient details of those tools in other published literatures.

3.12 MARKET BARRIERS

1. A market-led supply and distribution chain of solar PicoPV is grossly missing in Nepal. The Current deployment system is heavily dependent on the government subsidies and hence, private sector is not investing its own capital for building a distribution and retailing system in Nepal. There is no major local manufacturer of solar PicoPV products in Nepal and the majority of solar companies do the trading as a local assembly unit.

2. Based on the market research it is found that manufacturing methods used to produce PLSs have become standardized over the past few years and this is also true for Nepal. While the basic components and the assembly processes essentially remain the same, emphasis on product quality varies from company to company, which has direct implications for economics. Manufacturing costs contribute between 30-50 % to the final retail price of the PLS, while the remaining 50-70 % of the retail price is associated with expenditure on tariffs, taxes, margins, distributor and retailer expenses, and on awareness and marketing. Very often, the profit margin for solar PicoPV varies from product to product and this creates negative consumer behavior in selecting products for their uses.

3. Interviews with several major manufacturers in the Nepal solar PicoPV market also indicated that, on average, irrespective of the channel used, in country distribution (including retail and margins across the supply chain) accounted for approximately 30-50 % of the final consumer price. According to them, any variation in distribution costs depended primarily on the number of intermediaries between the manufacturer and the consumer, and their respective margins. Hence, the long chain of intermediaries is a negative market force.

4. Absence of access to finance options in the PLS market is a major impediment to its growth. Discussions with stakeholders have revealed that traditional financing solutions available to consumer goods markets cannot be directly applied to this sector, which requires tailored financial solutions.

The PLS market is significantly different from other markets in that it: serves customers at the base of the economic pyramid; caters largely to remote rural areas; often requires after-sales support; and is a nascent market that benefits from the funding and support of socially driven institutions. Based on the secondary source of data and analysis, carried out by Dalberg research and analysis (2012), the following key differences between the solar PicoPV market and other consumer goods markets are noted:

Table 20: differences between the solar PicoPV market and other consumer goods markets

Market characteristic	Implication for access for finance
The Solar PicoPV market caters primarily to a consumer base at the base of the pyramid.	This requires financing mechanisms to be a core part of the sales process and business Model. Without financing, most consumers would be unable to afford Solar PicoPV.
Solar PicoPV need to be distributed in remote, rural areas.	Traditional finance institutions have limited reach in these areas
The Solar PicoPV market is still nascent and needs to achieve scale.	Credit institutions and investors need to be convinced of the products and viability of the Solar PicoPV business, which faces some disadvantages as it is (1) a nascent industry, (2) established on a relatively new technology platform, and (3) relatively unknown with limited market information available.
The Solar PicoPV market has high social impact and benefits from the support of socially driven institutions and funding.	The social benefits gained from the expansion of the Solar PicoPV industry in turn attracts socially driven institutional players and funding in the form of subsidized funds and investment, policy initiatives and subsidies, refunds through programs like emissions trading, collective buying and consumer awareness programs.
Companies entering this space have thus far typically been small start-up enterprises.	These small- and medium-sized enterprises find it very difficult to access sufficient levels of financing, as they are constrained by the lack of a track record, and a small balance sheet.

While access to financing solutions are needed across the Solar Pico PV value chain, distributors and end users need them most. From stakeholder discussions, it was evident that these two primary challenges – identifying working capital for wholesalers/retail distributors and ensuring affordability for the end users – were the most urgent to ensure growth in this sector.

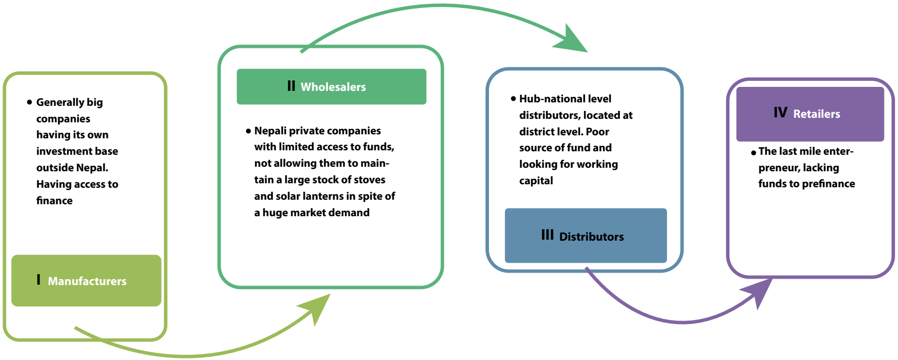


Figure 43: Identifying working capital

5. Consumer's education and marketing

Nepal has poor planning for marketing and increasing general solar lighting awareness and education, as well as convincing potential customers that solar PicoPVs are superior to traditional lighting sources. Many potential consumers are unaware of quality solar-powered lighting products and their benefits. Among those who are aware of the products, there is the misperception that solar PicoPV are more expensive than kerosene and biomass lighting. Awareness campaigns have therefore deemed necessary to convince customers that not only are they buying better, safer lighting that will improve the quality of their lives, but also that doing so will result in significant savings.

6. Adequate policies to promote private sector development in Nepal

The Government of Nepal needs to introduce compatible policies for attracting the private sector to invest in the solar picoPV sector without subsidy. This type of policy support could be in the form of tax benefits. For instance, in countries like Kenya, all imported LED-lighting equipment and solar components are exempt from taxation. This policy has the additional benefit of encouraging the local assembly of solar products, including solar PicoPV.

Governments in other countries inadvertently suppress demand for modern lighting devices by subsidizing the use of kerosene-based alternatives. In Ethiopia, kerosene is exempt from all taxes, which reduces its effective market price by approximately 30 %. Similar tax benefits, including usage-based discounts, reduce the price of kerosene by 18 % in Cameroon. In Ghana, industries pay higher prices for kerosene in order to keep consumer prices low. The elimination of these incentives will reduce the opportunity cost of switching to solar PicoPV.

7. Absence of effective monitoring and providing post installation services

Solar PicoPV price points combined with low levels of product penetration have limited manufacturers' ability to provide favorable and comprehensive after-sales practices cost-effectively. At the same time, end-users are often unaware that they are entitled to warranty and service, which inhibits the demand for such services. This leads them to simply write off a faulty product as a bad investment without seeking repair or maintenance. Nepal needs to focus on building a robust post installation care mechanism.

SWOT Analysis

As with any new product or product range, solar PicoPV systems have their strengths and weaknesses and also provide new opportunities while experiencing barriers. A preliminary SWOT analysis has been performed that may be helpful to guide the policies required to support their introduction.

STRENGTHS	OPPORTUNITIES
■ Portable PV system ■ Expandable, so extra services can be supplied ■ Much lower costs than SHS, so larger target group ■ No risk of “solar trap”	■ Millions of households will not be connected to grids in years to come ■ Combining mobile phone payments with phone charging
WEAKNESSES	**THREATS**
■ Output relatively modest ■ For majority of potential users credit sales still required ■ Systems with in-built solar panels have to be put in the sun manually	■ Devices with in-built solar panels can easily be stolen ■ Quality assurance must be provided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4. KEY FINDINGS

4.1 KEY FINDINGS

A. Overall Lighting Energy Situation

- Considering the national census survey of Nepal (2011): 1.37 million households (26 % of total households) in Nepal do not have access to electricity;
- Among 4.05 million electrified households (75 % of total households), 80 % are connected to the national grid, 10 % are consumers of mini/micro hydro and the rest (10 %) have Solar PV Systems;
- 991,510 un-electrified households (70 % of total non-electrified households) are still using kerosene lamps for lighting.

B. Existing Market Structures

- The Solar PV market is characterised by three technologies used in rural areas: solar lantern, Small Solar Home Systems (SSHS) and Solar Home Systems;
- In total, over 410,430 systems are installed all over Nepal, 20 Wp (85 % of total installation) being the most popular among the users;
- In total this sector is represented by 108 companies among them 75 are pre-qualified for GON subsidy scheme;
- The total cost of the solar lantern varies from 900 to 3,000 NRs; SSHS (10 Wp) varies from 8,500 to 9,5000 NRs, whereas the cost range of SHS (20 Wp) is from 14,000 to 16,000 NRS;
- Over the last 5 years the unit cost of the SHS has decreased in average by 30 %;
- The study revealed that the users' save 1500 NRs per system if the system is distributed under subsidy scheme, meaning that only 25 % of the allocated subsidy actually reaches the household, the rest is spent during inefficient service delivery.

C. Major Players

- AEPC provides subsidies, capacity building, conducts monitoring & evaluation, QA/QC, evaluation of Subsidy Application forms submitted by PQ companies, keeps record of SHSs;
- significant technical assistance and subsidy amounts are provided by various

External Development Partners including Danida, Norway, KfW, EU etc.;

- 75 PQ companies create demand, raise local awareness, and install Solar PV Systems on credit at subsidized rate through agents & dealers, prepare documents for subsidy claim, provide after sales services;
- SEMAN monitors the Solar PV Industry in Nepal and works to promote and professionally develop all the Solar PV Companies;
- RETs conduct tests of different solar products and accessories in line with the NEPQA guidelines

D. Users' Characteristics in Survey Area

- Majority of population in the study area still use traditional lighting source "Jharoo" for lighting purpose.
- Lighting sources for non-electrified HH constitutes 40 % from Jharro; 19 % use batteries; 12 % rely on kerosene lamps and 8 % use candles;
- Mobile is the most used electric appliance followed by radio among surveyed households. Few HHs use TV and Computer;
- Users' minimum requirement for solar PV system is that the system will have 3 bulbs and a mobile charging facility;
- Capacity of a solar system was seen as major issues in the study area as lesser than 10 Wp cannot be seen as viable option for rural household.
- The majority (65 %) of the households in the study area use 15-25 Wp systems; 20 % use 35-50 Wp systems; 10 % adopted systems above 50 Wp and less than 5 % use systems below 15 Wp.
- White LED bulbs found to be used in majority (58 %) in the study area; while CFL bulbs are used in households which have above 20 Wp systems;
- The kitchen is the place where most of HHs use solar lights, followed by places like study area, balcony and toilet;
- The average use of a solar light is 3.8 hours per day;
- Light provided by solar PV is found to be sufficient for household lighting

requirements;

- Investment in solar is mainly done by users, subsidy and loan. Approximately 75 % of users claimed that they have installed SHS with their own money; 16 % of users installed SHS under subsidy scheme; 5 % from remittance and 4 % from loan.
- Only 9 % of non-solar users agreed to cover full installation cost of the SHS; 66 % of users preferred shared upfront and instalment financing and remaining 25 % opt for full credit financing

E. HH Energy Expenditure

- In average the energy expenditure of household is found as 3 % of total household expenditure;
- Solar user spends NRs. 79 for lightning needs, whereas non user spends NRs. 151 for lightning purpose;
- With the amount spent for lighting purposes by non-solar users, it is enough to install SHS using credit facility with the average payback period of around 5 years.

F. Market Potential

- The Solar PV market potential is estimated as NRs. 8,220 million rupees assuming that around 50 % of non-electrified households will install SHS in the future.

G. Subsidy Dominated Solar PV Market

- The solar market in the surveyed district is heavily influenced by the fluctuation in subsidy policy and its delivery mechanism;
- Users are paying actual price of the product and considerable amount of the subsidy goes to the companies, as a result solar systems without subsidy are found to be cheaper;
- Local retailers are promoting only the subsidized products; less priority is given to non-subsidised products;
- Promotion/Installation and After Sales Service in study areas is mainly done by local retailers/dealers who are not pre-qualified for AEPC subsidy scheme;
- Price of the products are determined by

the PQ companies.

H. After Sales Services and Cost of Repairs

- No proper channel for after sales services exists;
- Non-functioning components are normally replaced rather than repaired during the warranty period;
- After the warranty period, people discard the products as no channel for repair and maintenance is found.

I. Credit Financing

- Banks and other financial institutions were found to be sufficient in the study areas; however none of them are engaged in RE financing since no demand for these systems is reported;
- There is a gap in possible credit financing investment directly related to access to RETs. On one hand, the users are willing to have a credit investment for technology, but are not aware on it; on the other hand, LFIs are in a position to provide loan, however no such demand is received.

J. Demand of Solar PV

- SSHS are primarily targeted for poorest of the poor segment of the population;
- Local people are aware on benefits of solar PV and above 90 % of the non-users are willing to install solar PV;
- Upfront payment has been identified as major constraint to have SHS.

K. Willingness to Pay

- The WTP analysis showed that the non-users are willing to pay NRs 1159 (128 % of the total cost) for the solar lantern; for solar picoPV system the users are willing to pay around 40 % or NRs. 2835 of the total cost; for SHS the users can invest up to NRs. 7438 (41 % of system cost);
- WTP for rent to buy solar lantern, solar picoPV and SHS are found as NRs. 82, NRs. 187 and NRs. 382 respectively;
- There exists relation between income and purchasing/renting of SHS and Pico pV. The higher income leads to more purchasing/renting chances of SHS and Pico PV. There is no relation between income and WTP for purchasing/renting of solar lantern.


SOLAR CHARGE CONTROLLER
sun
Supreme
Solar

5. CONCLUSIONS

5.1 NEPAL’S SOLAR PICOPV MARKET ASSESSMENT CONCLUSIONS

With only two third of the population connected to the national grid and the rest still relying on traditional sources of power, solar energy has been identified as one of the viable alternative sources for providing ‘pre-electrification facilities’. There exists potential of electrifying 1.37 million households by various means, including solar PV.

The existing lighting requirement of the typical rural household is 3-4 bulbs and a mobile charger device, which could be easily supplied by SHS.

The existing trend of solar systems installation clearly shows the popularity of 20 Wp systems in Nepal. This could be considered for promotion. The existing regional coverage of the solar companies in promoting and installing solar products needs strengthening and particularly the after sales services needs acute and robust strengthening. The cost of the solar technology in Nepal is decreasing but not as in the global market. The major reason being that the Nepalese solar market is limited by importer/wholesalers.

The subsidy has contributed less to the users: the majority of the amount is spent on inefficient service delivery.

The solar non-users are still spending a considerable amount on lighting energy, which could be sufficient to cover expenses if a solar product is installed using credit financing.

Willingness to pay of the people is greater than the current energy expenses which signifies people’s interest to replace the traditional energy and willingness to advance to other energy sources.

Among non-electrified households the demand for solar technology is high, with non-affordability to cover upfront investment being the main barrier for the promotion of this technology. The credit financing could be a major intervention for attracting these households to shift to cleaner lighting solutions. To achieve that, rigorous capacity building activities among LFIs should be initiated.

Pico solar PV systems represent a new dimension, largely underestimated by decision makers, in the landscape of fighting the energy poverty that can be a genuine source of social unrest. Due to their much lower initial investment costs they are also becoming affordable in the absence of government-subsidized programmes. The following recommendations can be considered by the key market actors to promote solar Pico PV market in Nepal.

Table 21: Key market actors to promote solar Pico PV market in Nepal

Market actor(s)	Do's	Don't	Remarks
Government agencies	Provide and disseminate reliable information: pros & cons; Establish and support a fully transparent QA scheme; Link QA products to soft loans.	Interfere with the market by providing direct subsidies; Provide subsidies for kerosene etc.; Consider an area / HH covered by pico PV systems as electrified.	Establish an enabling framework but stay out of the market. Only nominal payment for a test-label for a product. Micro-credit schemes can be backed by government guarantees.
Finance sector	Provide micro-credit to QA products; Accept pico PV as collateral via retailers.	Leave administration of micro-credit to retailers / NGO's – otherwise transaction cost will be too high	Micro-credit to be administered by retailers or NGO's. Minimum down payment of 25 % - 30 % to back collateral.

Certification institutes	Simple test-labeling QA scheme including follow up testing	Introduce non-tariff trade barriers by certification procedures	Any measure increasing transaction cost must be justified by economic gains, such as improved life cycle costs.
Commercial/retailers	Try to establish industry associations with a clear code of conduct	Push people working in the informal sector out of business, without giving them a genuine chance to become formal members of the sector	Most pico PV dealers would prefer to have a proper, registered business but they would need an affordable shop and, for example, two years VAT exemption.
Users (customers)	Ask the dealer for a guarantee period of the product; Women could be a powerful driver in promoting the use of solar pico PV systems.	Take a micro-credit where the payback period is longer than the lifespan of the product.	Poor people risk entering a poverty trap if they spend money servicing an uneconomic loan.
Donors	Support all the above measures via capacity building and funding.	Subsidize hardware; Consider this the means to achieve electrification goals.	Subsidizing hardware is distorting markets and does not benefit poor people.

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Annexure-1:

List of qualified companies for Solar Energy System				
Table 1: List of companies prequalified to participate in NRREP/AEPC subsidy programme for Institutional Solar Power System including Solar Photovoltaic Pumping System (ISPS)				
SN	Company	Address	Phone	E-mail
1	Locus Nepal Pvt. Ltd.	Kathmandu	01-4427264	locusnep@gmail.com
2	Surya Power Company Pvt. Ltd.	Bafal	01-4288388	rajiv@suryapowerco.com
Table 2: List of companies prequalified to participate in NRREP/AEPC subsidy programme for Small Solar Home System and Solar Home System (S/SHS) and Institutional Solar Power System including Solar Photovoltaic Pumping System (ISPS)				
SN	Company	Address	Phone	E-mail
1	Bio Energy Pvt. Ltd.	Nepalgunj	081-526837	bioenergy@ntc.net.np
2	Clean Homes Energy Nepal Pvt. Ltd.	Balaju	01-4310381	cleanhomesenergy@ntc.net.np
3	Clean Homes Investment Pvt. Ltd.	Balaju	01-4389610	cleanhomesinvest@yahoo.com
4	Dhaulagiri Solar and Electronic Company Pvt. Ltd.	Balaju	01-4365376	dhaulagirisolar@ntc.net.np
5	Deeplight Energy Pvt. Ltd.	Maiti	01-4387678	info@deeplightenergy.com
6	Dibya Urja Pvt. Ltd.	Narayangopal Chowk	01-4720998	dibyaurja@wlink.com.np
7	Everest Solar Energy Pvt. Ltd.	Gongabu	01-4360086	ese@ntc.net.np
8	Energy International Pvt. Ltd.	Jwagal	01-5527307	info@energy_international.com.np
9	Energy and Construction Pvt. Ltd.	Kalanki	01-4277196	ecnepal@ntc.net.np
10	Gham Power Nepal Pvt. Ltd.	Kathmandu	01-4438950	ghampower@ghampower.com
11	Kathmandu Power Company Pvt. Ltd.	Kathmandu	01-4424515	sailesh@kpc.com.np
12	Krishna Grill and Engineering Works Pvt. Ltd.	Biratnagar	021-471492	kgbw_brt@wlink.com.np
13	Lotus Energy Pvt. Ltd.	Bhatbhateni	01-4418203	info@lotusenergy.com.np
14	Lumyra Energy Pvt. Ltd.	Lalitpur	01-5535972	info@lumyraenergy.com.np
15	Laserina Energy Pvt. Ltd.	Indreni Height	01-5549607	info@laserinaenergy.com
16	LS Solar Asia Pvt. Ltd.	Sanepa	01-5543231	tanka@lssolarasia.com
17	Manasalu Energy Pvt. Ltd.	Chabahil	01-4823015	manasalu.energy@gmail.com
18	Nabaryon Urja Pvt. Ltd.	Dhapashi	01-4358806	nabaryon.urja@yahoo.com
19	Nabikaraniya Urja Pvt. Ltd.	Dhapashi	01-4387026	nabikaraniyaurja@gmail.com
20	National Solar and Investment Pvt. Ltd.	Kohalpur	081-541755	solar.national@yahoo.com
21	Nepal Energy Development Company Pvt. Ltd.	Ekantakuna	01-5000672	nedco@ntc.net.np
22	Perennial Energy Nepal Pvt. Ltd.	Naxal	01-4414363	perennial_nepal@yahoo.com
23	Public Solar Pvt. Ltd.	Tallo Bazar	083-691412	publicsolar@gmail.com
24	PSS Renewable Energy Nepal Pvt. Ltd.	Ichangu Narayan	01-4891451	[illegible]
25	Rural and Alternative Energy Pvt. Ltd.	Damauli	065-560573	[illegible]@wlink.com.np
26	Renewable Nepal Alternative Energy Pvt. Ltd.	Sinamangal	01-4282198	rnaenergy@yahoo.com
27	Suryodaya Urja Pvt. Ltd.	Dhapashi	01-4379000	info@suryodaya.wlink.com.np
28	Sourya Energy Pvt. Ltd.	Chabahil	01-4822472	souryaenergy@ntc.net.np
29	Sun Power Pvt. Ltd.	Baluwatar	01-4440354	sunpowernp@gmail.com
30	Sunsafe Solar and Investment Pvt. Ltd.	Banasthali	01-4385114	Sunsafesolar12@gmail.com
31	Swavimaan Urja Bikash Company Pvt. Ltd.	Samakhusi chowk	01-4384632	swavimaanurja@gmail.com
32	Sourya Urja Nepal Pvt. Ltd.	Dumbarahi	01-6225365	souryaurjanepal@ntc.net.np
33	Sunshine Energy Pvt. Ltd.	Samakhusi Chowk	01-4383095	info@sunshine.com.np
34	Siprad Energy Pvt. Ltd.	Naikap	01-4311301	prem.neupane@siprad.com.np
35	Swagma Energy Pvt. Ltd.	Samakhusi	01-4362505	swogma@ntc.net.np
36	Sprint International Pvt. Ltd.	Baluwatar	01-4430417	sprint@wlink.com.np
37	Solar Electricity Company Pvt. Ltd.	Bagbazar	01-4225253	sec@vianet.com.np
38	Sunlight Solar Company Pvt. Ltd.	Kalanki	01-4037158	info@sunlightsolar.com.np
39	[illegible]	[illegible]	[illegible]	[illegible]

SN	Company	Address	Phone	E-mail
39	Topsun Energy Pvt. Ltd.	Ichangu Narayan	01-4891268	kiran.gautam@ntc.net.np
40	Urja Ghar Pvt. Ltd.	Balaju	01-4388438	urjaghar@wlink.com.np
41	Ultra Solar Energy and Steel Engineering Pvt. Ltd.	New Naikap	01-4313398	md@ultragroup.com.np

Table 3: List of companies prequalified to participate in NRREP/AEPC subsidy programme for Small Solar Home System and Solar Home System (S/SHS)

SN	Company	Address	Phone	E-mail
1	Bright Energy Pvt. Ltd.	Chabahil	01-4462410	brightenergy120@yahoo.com
2	Bright Sun Company Pvt. Ltd.	Sitapaila, Milan Tol	01-4034855	info@brightsunco.com
3	Energy Prabardhan Company Pvt. Ltd.	Gongabu	01-4353697	info@energyprabardhan.com.np
4	Globalmatics Renewable Energy Pvt. Ltd JV Danphe Energy Pvt. Ltd. JV Lek Besi Sourya Urja and Gobar Gas Sewa Company Pvt. Ltd.	Balkhu	01-5546076	mladhar16@yahoo.com
5	GUP Pvt. Ltd.	Tripureshwor	01-4228779	gup@eastlink.net.np
6	Himal Refrigeration and Electrical Industries Pvt. Ltd	Sanepa, Gusingal	01-5012590	himalref@wlink.com
7	Kinetic Energy Pvt. Ltd.	Chabahil, Hayatt Gate	01-4499668	info@kineticenergy.com.np
8	Kaligandaki Solar and Electronic Pvt. Ltd.	Gongabu	01-4352279	kaligandakisolar@gmail.com
9	Narayani Power Solutions Pvt. Ltd.	Bharatpur	056-570268	info@narayanipower.com.np
10	Peak Sun and Investment Pvt. Ltd.	Balaju	01-4359857	peaksun_energy@yahoo.com
11	Priemier Energy and Electronics Company Pvt. Ltd.	Banasthali	01-4397473	priemierenergy@ntc.net.np
12	Poulatsya Sourya Energy and Investment Pvt. Ltd. JV AG Power Company Pvt. Ltd.	Gongabu	01-4359347	pocsolar2012@gmail.com
13	Rastriya Gramin Tatha Baikalpik Urja Bikas Pvt. Ltd.	Bhimdatta Marga	099-520068	national_energy@yahoo.com
14	JV between Swargadwari Solar and Electronic Com Pvt. Ltd. Solar Homes Pvt. Ltd and Kathmandu Energy Pvt. Ltd.	Balaju	01-4382608	netrakpengi@gmail.com
15	Renewable Global Energy Pvt. Ltd.	Sanepa	01-5551135	renewableglobalenergy@gmail.com
16	Sunlife Energy Pvt. Ltd.	Maitighar	01-5537803	sunlife.energy@yahoo.com
17	Suryodaya Hi Tech Pvt. Ltd.	Dhapasi	01-4374611	binod@suryodayaurja.com
18	Sunera Energy Pvt. Ltd.	Kalanki	01-4283697	sunerаenergy@gmail.com
19	Shikhar Renewable Energy Pvt. Ltd	Dhumbarahi	01-4375533	shikharrenewable@ntc.net.np
20	Suryajyoti Mahila Maitri Urja Pvt. Ltd.	Dumbarahi	01-4008535	suryajyoti@hons.com.np
21	Smart Power Pvt. Ltd.	Ganesh Sadan Thamel	01-4413362	babin@smart.power.com.np
22	Sunforce Solar Energy and Investment Pvt. Ltd.	Sano Bharyang	01-4673198	sunforceenergy@gmail.com
23	Scientific Technology Pvt. Ltd.	Kupondole	01-5548150	stl_company@yahoo.com
24	Suntech Energy Co. Pvt. Ltd	Koteswor	01-4281995	setc_2004@hotmail.com
25	Surya Deep Urja Pvt. Ltd. JV Total Solutions Pvt. Ltd.	Ghorahi	082-562721	suryodeepurja@yahoo.com
26	Unique Energy Nepal Pvt. Ltd.	Balaju	01-4359789	uniqueenergy@ntc.net.np
27	Unique Nepal Solar Pvt. Ltd JV Subham Traders and General Suppliers	Kalanki	01-4037149	uniquenepalsolar1@gmail.com
28	Ujyalo Urja Pvt. Ltd.	Balaju	01-4383358	ujyalourja2010@gmail.com

Table 4: List of companies prequalified to participate in NRREP/AEPC subsidy programme for Solar Thermal System

SN	Company	Address	Phone	E-mail
1	Grameen Urja Tatha Prabidhi Sewa	Kumaripati	01-5537556	getsc@crtnepal.org
2	Krishna Grill Pvt. Ltd.	Biratnagar	021-471492	kgletc_brt@wlink.com.np
3	Nepal Power Solution Pvt. Ltd.	Hetauda	057-526606	npshetauda@gmail.com
4	Rural and Alternative Energy Pvt. Ltd.	Damauli	065-560573	reurja.bnl@gmail.com
5	Sunworks Nepal	Balkhu	01-4330854	niraz@engineer.com
6	Ultra Solar Energy and Steel Engineering Pvt. Ltd.	New Naikap	01-4313398	info@ultragroup.com.np

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